

Keysight 3458A Multimeter

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	Direct current (DC)		Alternating current (AC)
	WARNING, RISK OF ELECTRIC SHOCK.		Instruction manual symbol affixed to product. Indicates that the user must refer to the manual for specific WARNING or CAUTION information to avoid personal injury or damage to the product.
	Indicates the field wiring terminal that must be connected to earth ground before operating the equipment – protects against electrical shock in case of fault.		Frame or chassis ground terminal—typically connects to the equipment's metal frame.

Safety Considerations

Read the information below before using this instrument.

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards for design, manufacture, and intended use of the instrument. Keysight Technologies assumes no liability for the customer's failure to comply with these requirements.

WARNING

- **Ground the equipment:** For Safety Class 1 equipment (equipment having a protective earth terminal), an uninterruptible safety earth ground must be provided from the mains power source to the product input wiring terminals or supplied power cable.
- **DO NOT** operate the product in an explosive atmosphere or in the presence of flammable gases or fumes.
- **For continued protection** against fire, replace the line fuse(s) only with fuse(s) of the same voltage and current rating and type. DO NOT use repaired fuses or short-circuited fuse holders.
- **Keep away from live circuits:** Operating personnel must not remove equipment covers or shields. Procedures involving the removal of covers or shields are for use by service-trained personnel only. Under certain conditions, dangerous voltages may exist even with the equipment switched off. To avoid dangerous electrical shock, DO NOT perform procedures involving cover or shield removal unless you are qualified to do so.
- **DO NOT operate damaged equipment:** Whenever it is possible that the safety protection features built into this product have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the product until safe operation can be verified by service-trained personnel. If necessary, return the product to Keysight for service and repair to ensure that safety features are maintained.

WARNING

- **DO NOT service or adjust alone:** Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.
 - **DO NOT substitute parts or modify equipment:** Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the product. Return the product to Keysight for service and repair to ensure that safety features are maintained.
 - **Measuring high voltages is always hazardous:** ALL multimeter input terminals (both front and rear) must be considered hazardous whenever inputs greater than 42V (dc or peak) are connected to ANY input terminal.
 - **Permanent wiring of hazardous voltage** or sources capable of delivering greater than 150 VA should be labeled, fused, or in some other way protected against accidental bridging or equipment failure.
 - **DO NOT** leave measurement terminals energized when not in use.
 - **DO NOT** use the front/rear switch to multiplex hazardous signals between the front and rear terminals of the multimeter.
 - To prevent electrical shock, disconnect the instrument from AC mains power and disconnect all test leads before cleaning. Clean outside of the instrument using a soft, lint-free, cloth slightly dampened with water. DO NOT use detergent or solvents. DO NOT attempt to clean internally. If needed, contact a Keysight Technologies Sales and Service office to arrange for a proper cleaning to ensure that safety features and performance are maintained.
-

CAUTION

This is a sensitive measurement apparatus by design and may have some performance loss when exposed to ambient continuous electromagnetic phenomenon.

Environmental Conditions

The 3458A is designed for indoor use and in an area with low condensation. The table below shows the general environmental requirements for this instrument.

Environmental condition	Requirement
Temperature	Operating condition – 0 °C to 55 °C
Humidity	Operating condition – Up to 95% RH at 40 °C (non-condensing) – Up to 40% RH for 41 °C to 55 °C (non-condensing)
Altitude	Up to 2000 m
Pollution degree	2
Installation category	II
Measurement voltage category	II
Overvoltage protection	II
Power requirements	100/120V, 220/240 V $\pm$ 10% 48 - 66 Hz, 360 - 420 Hz automatically sensed < 30 W, < 80 VA (peak) Fused: 1.5 @ 115 V or 0.5 A @ 230 V

WARNING

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE OR WET ENVIRONMENTS
Do not operate the instrument around flammable gases or fumes, vapor, or wet environments.

Product Regulatory and Compliance

The 3458A digital multimeter complies with safety and EMC requirements.

Refer to Declaration of Conformity at <http://www.keysight.com/go/conformity> for the latest revision.

Waste Electrical and Electronic Equipment (WEEE) Directive

This instrument complies with the WEEE Directive marking requirement. This affixed product label indicates that you must not discard this electrical or electronic product in domestic household waste.

Product category:

With reference to the equipment types in the WEEE directive Annex 1, this instrument is classified as a “Monitoring and Control Instrument” product.

The affixed product label is as shown below.



Do not dispose in domestic household waste.

To return this unwanted instrument, contact your nearest Keysight Service Center, or visit <http://about.keysight.com/en/companyinfo/environment/takeback.shtml> for more information.

Sales and Technical Support

To contact Keysight for sales and technical support, refer to the support links on the following Keysight websites:

- www.keysight.com/find/3458A
(product-specific information and support, software and documentation updates)
- www.keysight.com/find/assist
(worldwide contact information for repair and service)

Preface

This manual contains installation information, operating and programming information, and configuration information for the 3458A multimeter. The manual consists of the following chapters:

Chapter 1 Installation and Maintenance

This chapter contains information on initial inspection, installation, and maintenance. It also contains lists of the multimeter's available options and accessories.

Chapter 2 Getting Started

This chapter covers the fundamentals of multimeter operation. It shows you how to use the multimeter's front panel, how to send commands to the multimeter from remote, and how to retrieve data from remote.

Chapter 3 Configuring for Measurements

This chapter shows how to configure the multimeter for all types of measurements except digitizing (digitizing is covered in Chapter 5). This chapter also shows you how to use subprogram and state memory, the input buffer, and the status register.

Chapter 4 Making Measurements

This chapter discusses the methods for triggering measurements, discusses the reading formats, shows how to use reading memory, and how to transfer readings across the GPIB bus. This chapter also discusses how to increase the reading rate, how to use the multimeter's EXTOUT signal, and how to use the math operations.

Chapter 5 Digitizing

Digitizing is the process of converting a continuous analog signal into a series of discrete samples (readings). This chapter discusses the various ways to digitize signals, the importance of the sampling rate, and how to use level triggering.

Chapter 6 Command Reference

This chapter discusses the multimeter's language (HPML) and contains detailed descriptions of each command in the language. Commands are listed in alphabetical order.

Chapter 7 BASIC Programming Language

This chapter describes the BASIC commands supported by the 3458A's internal BASIC language operating system. With this feature, many of your special requirements can be easily satisfied by writing and downloading a simple BASIC subprogram to customize the multimeter's behavior.

Appendices

The appendices contain the multimeter's specifications, information on the GPIB commands recognized by the multimeter, information on locking-out the front/rear terminals switch, and contains product notes concerning digitizing and maximizing the multimeter's reading rate and throughput.

Table of Contents

Safety Symbols	3
Safety Considerations	4
Measurement Category <valid for HH UG only - remove this>	5
Environmental Conditions	6
Regulatory Information	7
Safety compliance	7
EMC compliance	7
Regulatory Markings	8
Waste Electrical and Electronic Equipment (WEEE) Directive	9
Product category:	9
Sales and Technical Support	9
1 Installation and Maintenance	
Introduction	30
Initial Inspection	31
Options and Accessories	32
Installing the Multimeter	34
Grounding requirements	34
Line power requirements	35
Setting the line voltage switches	35
Installing the line power fuse	36
Power cords	37
Connecting the GPIB cable	38
The GPIB address	39
Mounting the multimeter	39
Installation verification	39
Maintenance	40
Replacing the line power fuse	40
Replacing a current fuse	40
Repair service	41

2 Getting Started

Introduction	44
Before Applying Power	45
Applying Power	46
Power-on self-test	46
Power-on state	46
The display	48
Operating from the front panel	49
Making a measurement	50
Changing the measurement function	51
Autorange and manual ranging	52
Self-test	53
Reading the error register	54
Resetting the multimeter	55
Using the configuration keys	57
Using the MENU keys	61
Query commands	62
Display control	64
Digits displayed	66
Recall	66
User-defined keys	67
Installing the keyboard overlay	68
Operating from Remote	70
Input/Output statements	70
Reading the GPIB address	70
Changing the GPIB address	71
Sending a remote command	71
Getting data from the multimeter	71
The Local key	72

3 Configuring for Measurements

Introduction	74
General Configuration	75
Self-test	75

Reading the error registers	75
Calibration	76
Selecting the input terminals	78
Guarding	80
Suspending readings	81
Presetting the multimeter	81
Specifying a measurement function	83
Autorange	84
Specifying the range	85
Configuring for DC or Resistance Measurements	86
DC voltage	86
DC current	87
Resistance	89
Configuring the A/D converter	91
Autozero	95
Offset compensation	96
Fixed input resistance	96
Configuring for AC Measurements	98
AC or AC+DC voltage	98
AC or AC+DC current	101
Frequency or period	102
Specifying bandwidth	103
Setting the integration time	104
Specifying resolution	106
Configuring for Ratio Measurements	109
Specifying ratio measurements	110
Using Subprogram Memory	111
Storing a subprogram	111
Executing a subprogram	112
Suspending subprogram execution	112
Nested subprograms	113
Autostart subprogram	114
Compressing subprograms	114
Deleting subprograms	115
Using State Memory	116

Storing states	116
Recalling states	117
Deleting states	117
Using the Input Buffer	118
Using the Status Register	119
Reading the status register	120
Interrupts	121

4 Making Measurements

Introduction	124
Triggering Measurements	125
The trigger arm event	126
The trigger event	126
The sample event	126
Event choices	126
Making continuous readings	127
Making single readings	128
Making multiple readings	129
Multiple trigger arming	129
Making synchronous readings	130
Making timed readings	131
Making delayed readings	133
External triggering	134
Event combinations	136
Reading Formats	140
ASCII	140
Single and double integer	140
Single real	141
Using Reading Memory	144
Memory formats	144
Recalling readings	146
Sending Readings Across the Bus	149
Output formats	149
Output termination	151

Using the SINT or DINT output format	151
Using the SREAL output format	153
Using the DREAL output format	154
Increasing the Reading Rate	156
High-speed mode	156
Configuring for fast readings	157
High-speed transfer across GPIB	163
High-speed transfer from memory	165
Determining the reading rate	166
The EXTOUT Signal	168
Reading complete	170
Burst complete	171
Input complete	172
Aperture waveform	172
Service request	173
EXTOUT ONCE	174
Math Operations	175
Real-time vs. post-process	175
Enabling math operations	175
Math registers	177
NULL	178
SCALE	179
Percent	180
DB	181
DBM	182
Statistics	184
Pass/Fail	185
FILTER	187
RMS	188
Measuring temperature	189

5 Digitizing

Introduction	192
Digitizing Methods	193
The Sampling Rate	195

Level Triggering	197
Level triggering examples	197
Level filtering	200
DCV Digitizing	201
DCV remarks	202
DCV example	203
Direct-Sampling	205
Direct sampling remarks	206
Direct sampling example	207
Sub-Sampling	209
Sub-sampling fundamentals	209
The sync source event	211
Sub-sampling remarks	212
Sending samples to memory	214
Sending samples to the controller	215
Viewing Sampled Data	218
6 Command Reference	
Introduction	224
Language conventions	226
Command termination	226
Multiple commands	227
Parameters	227
Query commands	228
Commands by Functional Group	230
Commands vs. Measurement Functions	232
ACAL	234
ACBAND	235
ACDCI, ACDCV, ACI, ACV	237
ADDRESS	237
APER	238
ARANGE	239
AUXERR?	240
AZERO	242

BEEP	243
CAL	244
CALL	244
CALNUM?	245
CALSTR	246
COMPRESS	247
CONT	248
CSB	248
DCI, DCV	249
DEFEAT	249
DEFKEY	250
DELAY	252
DELSUB	253
DIAGNOST	254
DISP	254
DSAC, DSDC	255
EMASK	258
END	260
ERR?	261
ERRSTR?	263
EXTOUT	264
FIXEDZ	266
FREQ	267
FSOURCE	269
FUNC	270
ID?	275
INBUF	275
ISCALE?	277
LEVEL	280
LFILTER	282
LFREQ	283
LINE?	284
LOCK	285
MATH	286
MCOUNT?	289
MEM	289
MENU	291

MFORMAT	292
MMATH	294
MSIZE	298
NDIG	299
NPLC	300
NRDGS	303
OCOMP	306
OFORMAT	307
OHM, OHMF	313
OPT?	313
PAUSE	314
PER	316
PRESET	318
PURGE	320
QFORMAT	321
R	323
RANGE	323
RATIO	327
RES	328
RESET	331
REV?	333
RMATH	333
RMEM	335
RQS	337
RSTATE	338
SCAL	339
SCRATCH	339
SECURE	339
SETACV	341
SLOPE	342
SMATH	343
SRQ	345
SSAC, SSDC	345
SSPARM?	350
SSRC	351
SSTATE	355
STB?	357

SUB	358
SUBEND	361
SWEEP	362
T	365
TARM	365
TBUFF	368
TEMP?	369
TERM	370
TEST	371
TIMER	371
TONE	373
TRIG	373

7 BASIC Language for the 3458A

Introduction	378
How It Works	379
BASIC Language Commands	380
Variables and arrays	380
Math operations	381
Subprogram definition/deletion	381
Subprogram execution commands	381
Looping and branching	382
Binary programs	382
New Multimeter Commands	383
3458A BASIC Language Example Program	384
Variables and Arrays	386
Type declarations	386
Type conversions	387
Using variables	388
Arrays	389
General Purpose Math	391
Math operators	391
Math hierarchy	394
Math errors	395
Making comparisons work	395

Subprograms	397
Writing and Loading Subprograms	398
Subprogram Command Types	400
Definition/Deletion commands	400
Execution Commands	402
Conditional Statements in Subprograms	405
FOR...NEXT Loops	405
WHILE Loops	406
IF...THEN Branching	406
A Specifications	
B GPIB Commands	
Introduction	412
ABORT 7 (IFC)	413
CLEAR (DCL or SDC)	413
LOCAL (GTL)	414
LOCAL LOCKOUT (LLO)	414
REMOTE	415
SPOLL (Serial Poll)	416
TRIGGER (GET)	417
C Procedure to Lock Out Front/Rear Terminals and Guard Terminal Switches	
Introduction	420
Tools Required	421
Procedure	422
Covers removal procedure	422
Guard pushrod removal procedure	425
Front/Rear pushrod removal procedure	425
Switch cap installation procedure	429
Covers installation procedure	430
D Optimizing Throughout and Reading Rate	
Introducing the 3458A	434
Application oriented command language	434

Intrinsically slow measurements	434
Maximizing the Testing Speed	435
Program memory	435
State storage	435
Reading analysis	435
Task grouping and sequence	436
System uptime	436
Purpose	437
Topics covered in the product note include:	437
DC Volts, DC Current and Resistance	438
Optimizing through the DCV path	438
DC current	441
Resistance	441
Optimizing through the track-and-hold path (direct sampling and subsampling)	443
AC Volts and AC Current	445
Analog ACV	445
Synchronous ACV	445
Random ACV	445
Comparison of ACV modes	446
AC current	447
Frequency and period	447
Optimizing the Testing Process Through Task Allocation	449
Math operations	449
Data storage	449
Output formats	449
State storage and program memory	450
Measurement list	451
A Benchmark	452
Benchmark results	454
Still faster	459

E High Resolution Digitizing With the 3458A

Introduction	478

Speed with Resolution	479
Digitizing analog signals	479
Avoiding aliasing	480
Choice of Two Measurement Paths	482
Using the DCV path for direct sampling	482
Using the track-and-hold path for direct or sequential sampling ..	483
Capturing the Data	485
High Speed Data Transfers	489
Software help the wave form analysis library	489
Starter main program	491
Errors in Measurements	494
Amplitude errors	495
Trigger and timebase errors	499

List of Figures

Figure 1-1	Rear panel	34
Figure 1-2	AC line voltage switch positions	36
Figure 1-3	Power cords	37
Figure 1-4	Typical GPIB connections	38
Figure 1-5	Current terminal/fuse assembly	41
Figure 2-1	Front panel	49
Figure 2-2	Standard 2-wire (plus guard) measurements	50
Figure 2-3	Function keys	51
Figure 2-4	Display test	55
Figure 2-5	Configuration key functions	57
Figure 2-6	Keyboard overlay (Keysight part number 03458A-84303)	68
Figure 2-7	Installing the keyboard overlay	69
Figure 3-1	Voltage measurement connections	87
Figure 3-2	Current measurement connections	88
Figure 3-3	2-Wire ohms measurement connections	90
Figure 3-4	4-Wire ohms measurement connections	91
Figure 3-5	Ratio measurement connections	109
Figure 4-1	Triggering hierarchy	125
Figure 4-2	Multiple trigger arming	130
Figure 4-3	TIMER or SWEEP interval	132
Figure 4-4	DELAY with SWEEP (or TIMER)	133
Figure 4-5	A/D Converter event relationships	169
Figure 4-6	Using an external scanner	171
Figure 5-1	Digitized sine wave	192
Figure 5-2	Digitizing signal paths	193
Figure 5-3	Digitizing measurement connections	194
Figure 5-4	Aliasing caused by undersampling	195
Figure 5-5	Level triggering at zero crossing, positive slope	197
Figure 5-6	Level triggering, 50%, neg. slope, AC-coupled	199
Figure 5-7	Level triggering, -50%, pos. slope, AC-coupled	199
Figure 5-8	Level triggering, -25%, pos. slope, DC-coupled	200
Figure 5-9	Direct sampling	205
Figure 5-10	Sub-sampling example	210

Figure 5-11	Composite waveform	210
Figure 5-12	Typical synchronizing signal for EXT sync source	211
Figure 5-13	Typical plotted waveform	218
Figure C-1	3458A right side	422
Figure C-2	3458A left side	423
Figure C-3	Covers ground screws	424
Figure C-4	3458A rear view	424
Figure C-5	3458A inside bottom view	426
Figure C-6	Guard switch and pushrod location	427
Figure C-7	3458A inside top view	428
Figure C-8	Front/rear terminal switch and pushrod location	429
Figure C-9	Switch covers installation	430
Figure D-1	Shows the dependency of accuracy, reading rate, resolution, and noise on aperture or NPLC selected	439
Figure D-2	Settling time characteristic for resistance measurements assuming <200 pF shunt capacitance in the circuit tested. For small values of resistance, there is no real advantage to setting the delay to less than the default values. Resistance above 100 kW require longer settling times to reach final values: hence settling delay times for these values may save measurement time at the expense of measurement accuracy.	442
Figure D-3	Offset compensated ohms removes the effect of small series voltage sources such as thermocouple effects in the circuit. By measuring the voltage across the unknown resistance, V_e , with the current source off and then measuring the voltage across the unknown resistance with the current source on, the effect of V_e on the measurement is eliminated	443
Figure D-4	Signal path block diagram offers three techniques for ACV measurement	446
Figure D-5	Measurement list and scan list increase test throughput when used with External Increment tied to External Output and Channel close tied to external trigger	451
Figure D-6	Shows benchmark execution times for different	

	configurations	453
Figure E-1	In general, digital signal processing systems require a close look at various functions beginning with the analog signal and ending with results meaningful to the user.	480
Figure E-2	Direct sampling acquires the wave form in one pass of the input. Sequential sampling requires a repetitive signal where the period is reconstructed in several passes. The numbers shown represent samples acquired in one period of the input.	481
Figure E-3	The 3458A multimeter provides two different digitizing paths, the standard DCV path and a track-and-hold path.	483
Figure E-4	Capturing the pulse amplitude of narrow pulses requires the use of the 12 MHz track-and-hold path. Note, the minimum time between sample acquisition and trigger event is 175 nanoseconds.	484
Figure E-5	The trigger event choices shown provide the versatility needed to match a wide variety of applications.	485
Figure E-6	Digitizing with the standard triggering command. Trigger Arming, TARM SGL, 4 allows a measurement cycle to occur only 4 times, reducing the amount of data necessary to determine the ratio of the shaded areas in the input wave form.	486
Figure E-7	Once the trigger arming and trigger event conditions are satisfied, a burst of measurements can digitize a wave form as shown in this example.	487
Figure E-8	Using the 3458A as a phase/gain meter with a swept frequency generator for magnitude only Bode plots. The DUT can be characterized over frequency with a phase synchronous trigger to time the measurement.	488
Figure E-9	Here is a typical way to structure your own automatic measurement program using the Library Subprograms (not necessarily a complete list).	490
Figure E-10	Example of results generated using the Wave Form	

	Analysis Library.	493
Figure E-11	These digitizing error sources should be considered in any measurement.	495
Figure E-12	With static DC input levels, the analog-to-digital converter may exhibit an ideal transfer function as shown in 12a. With a dynamic input, however, errors shown in 12b may appear.	497
Figure E-13	Analog-to-digital converters that exhibit non-linearity errors cause spurious responses that averaging will not remove. The 3458A is linear to 16 bits at 100,000 readings/s.	498
Figure E-14	Amplitude roll-off of the 3458A multimeter for its two different measurement paths.	499
Figure E-15	The effects of timebase jitter is shown here. For the 3458A multimeter, the jitter is 50 ps RMS. This jitter is repeatable so it can be characterized and corrected.	500

List of Tables

Table 1-1	Available options	32
Table 1-2	Available accessories	32
Table 1-3	Line voltage limits	35
Table 1-4	Replacement power line fuses and caps	40
Table 2-1	Power-on state	46
Table 2-2	Display annunciators	48
Table 3-1	Input ratings	80
Table 3-2	PRESET NORM state	81
Table 3-3	Measurement function parameters	83
Table 3-4	DC voltage ranges	86
Table 3-5	DC current ranges	88
Table 3-6	Resistance ranges	89
Table 3-7	AC and AC+DC voltage measurement methods	99
Table 3-8	AC and AC+DC current ranges and resolution	102
Table 3-9	FSOURCE parameters	103
Table 3-10	Analog AC A/D converter relationships	106
Table 3-11	Frequency/Period gate time and resolution	107
Table 4-1	Event parameters	126
Table 4-2	Event combinations	136
Table 4-3	Commands executed by PRESET FAST	158
Table 4-4	Math registers	177
Table 4-5	STAT registers	184
Table 4-6	Temperature-related math operations	189
Table 5-1	Digitizing methods	193
Table 5-2	Amplitude error and resolution vs. aperture	203
Table 6-1	Commands vs. measurement functions	232
Table B-1	GPIB capabilities	412
Table D-1	Integration time and query response	440
Table D-2	Compares the ACV modes	446
Table D-3	Shows resolution trade off for each of the gate times.	447

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1 Installation and Maintenance

Introduction	30
Initial Inspection	31
Options and Accessories	32
Installing the Multimeter	34
Maintenance	40

Introduction

This chapter contains information on initial inspection, installation, and maintenance. It also contains lists of the multimeter's available options and accessories. It's a good idea to read this chapter before making any electrical connections to the multimeter.

Initial Inspection

WARNING

If any of the following symptoms exist, or are expected, remove the multimeter from service:

- Visible damage.
- Severe transport stress.
- Prolonged storage under adverse conditions.
- Failure to perform intended measurements or functions.

Do not use multimeter until safe operation can be verified by service trained personnel.

The multimeter was carefully inspected before it left the factory. It should be undamaged and in proper working order upon receipt. If the shipping container or cushioning material is damaged, keep it, until the contents of the shipment have been checked and the multimeter has been inspected. When you unpack the multimeter, verify that the following items are included:

- Line Power Cord (Qty. 1)
- Replacement line power fuses: 500 mA T (Qty 1 for 220/240 operation), 1.5 A NTD (Qty 1 for 100/120 operation)
- Keyboard Overlay (Qty. 5)
- Switch Lockout Caps (Qty. 2)
- Test Lead Kit (Qty. 1)

If the multimeter is damaged or the contents are incomplete, promptly notify the nearest Keysight Technologies office.

Options and Accessories

Table 1-1 lists the available options, and **Table 1-2** lists the available accessories for the multimeter.

Table 1-1 Available options

Description	Option number	Part number for field retrofit
Extended Reading Memory (expands to a total of 148k-bytes)	001	03458A-87901
High Stability Reference (4 ppm/year)	002	03458A-80002
Front Handle Kit	907	5063-9226
Rack Flange Kit	908	5063-9212
Rack Flange Kit (with handles)	909	5063-9219
2 Additional Years of Return to Keysight Hardware Support	W30	

Table 1-2 Available accessories

Description	Model or part number
Extra User's Guide, Quick Reference Guide, Calibration Manual, Assembly-Level Repair Manual, and Front Panel User's Guide	03458A-90101
Extra User's Guide to Keysight 3458A Front Panel Operation	03458A-90007
Extra Quick Reference Guide	03458A-90008
Extra Assembly-Level Repair Manual	03458A-90011
Extra Calibration Manual	03458A-90017
User-Defined Key Overlay	03458A-84313
Switch Lockout Cap (Qty 1)	03458A-44113
1 Meter GPIB Cable	10833A

Table 1-2 Available accessories (continued)

Description	Model or part number
2 Meter GPIB Cable	10833B
4 Meter GPIB Cable	10833C
0.5 Meter GPIB Cable	10833D
Test Lead Set	34137A
30 Amp Current Shunt	34330A
Kelvin Probe Set (4-wires plus ground, 1m each)	11059A
Kelvin Clip Set (2 each)	11062A
Thermistor Temperature Probe 5 k Ω	E2308A
10 k Ω Thermistor	34308A

Keysight 3458A User's Guide

The multimeter comes with a three-conductor AC power cable (see [Figure 1-3](#)). The power cable must be connected to an approved three-contact electrical outlet that has its ground conductor connected to an electrical ground (safety ground). The multimeter's power jack and the supplied power cable meet International Electrotechnical Commission (IEC) safety standards.



For protection from electrical shock, the power cord ground must not be defeated.

Line power requirements

You can operate the multimeter from a single phase power source delivering 100 VAC, 120 VAC, 220 VAC, or 240 VAC (all values RMS), at 48 to 440 Hz. The power line voltage can vary by +/- 10% but cannot exceed 250 VAC RMS. Maximum power consumption is 80 VA (Volt-Amps). The nominal line voltage values and their corresponding limits are shown in [Table 1-3](#).

CAUTION

Possible multimeter damage. Before connecting the multimeter to an AC power source, verify that the multimeter's line voltage selection switches are set to match the AC line voltage and that the proper line fuse is installed. These topics are discussed in the following sections.

Table 1-3 Line voltage limits

Nominal value (RMS)	Allowable limits (RMS)
100 VAC	90 VAC to 110 VAC
120 VAC	108 VAC to 132 VAC
220 VAC	198 VAC to 242 VAC
240 VAC	216 VAC to 250 VAC

Setting the line voltage switches

The line voltage selection is pre-configured according to the country to which it is shipped. Use the following procedure if you need to change this setting:

- 1 Remove the multimeter's line power cord before changing the positions of the AC line voltage selection switches
- 2 With a small flat blade screwdriver, move the switches to the appropriate positions as shown in [Figure 1-2](#)
- 3 Install the correct line power fuse as described in the next section.

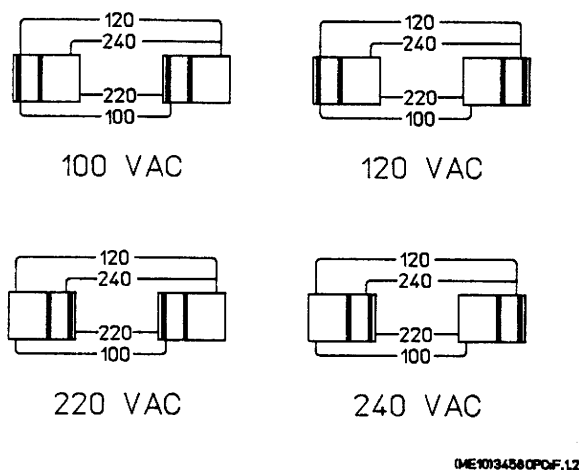


Figure 1-2 AC line voltage switch positions

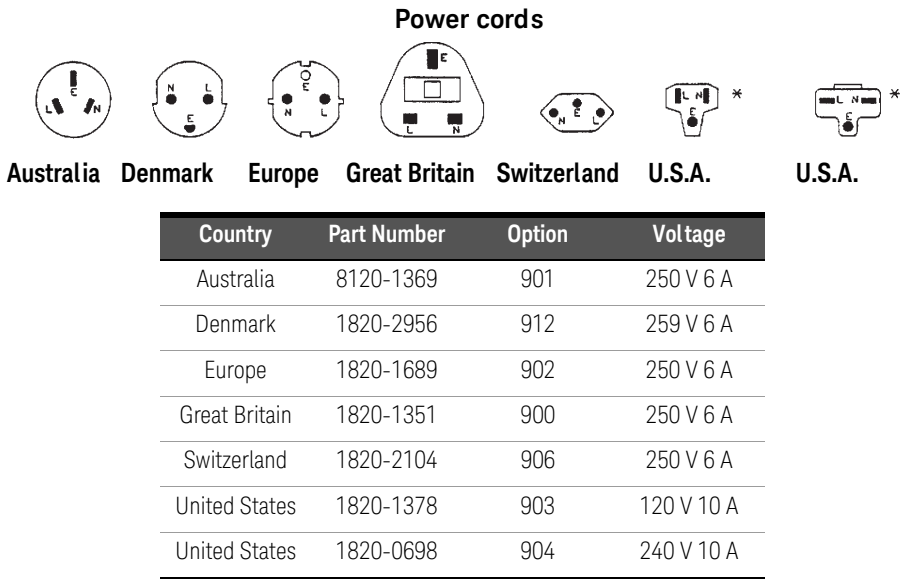
Installing the line power fuse

The line power fuse must match the line voltage selection. For 100 VAC or 120 VAC operation install a 1.5 A fuse. For 220 VAC or 240 VAC operation install a 500 mA fuse.

The line power fuse holder is located on the right side of the multimeter's rear panel (see [Figure 1-1](#)). To install a fuse, make sure the multimeter's power cord is removed. Insert one end of the fuse into the fuse cap. Insert the fuse/cap assembly into the fuse holder. With a small flatblade screwdriver, push in on the fuse cap and rotate it clockwise.

Power cords

Figure 1-3 shows the various multimeter power cords and their Keysight part numbers. If you received the wrong power cord, notify your Keysight sales office for replacement.



Power cords supplied by Keysight have polarities matched to the power input socket on the instrument.

NOTE: Plugs are viewed from connector and shape of molded plug may vary within country.

*CSA certification includes only these power cords.

Figure 1-3 Power cords

Connecting the GPIB cable

Attach the GPIB^[1] cable to the 24-pin GPIB connector on the rear panel of the multimeter. Finger tighten the two screws on the cable connector. **Figure 1-4** shows a typical GPIB connection between the multimeter and a controller.

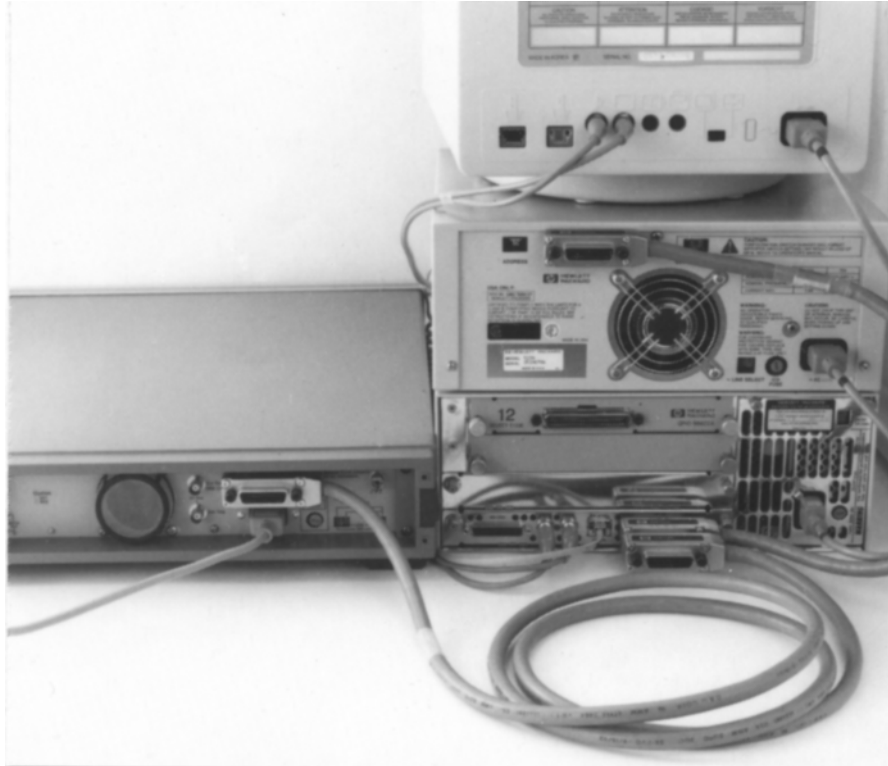


Figure 1-4 Typical GPIB connections

A total of 15 devices can be connected together on the same GPIB bus. The cables have single male/female connectors on each end so that several cables can be stacked. The length of the GPIB cables *must not* exceed 20 meters (65 feet) total, or 2 meters (6.5 feet) per device, whichever is less.

[1] GPIB (General Purpose Interface Bus) is an implementation of IEEE Standard 488-1978 and ANSI MC 1.1.

The GPIB address

You can change the multimeter's GPIB address using the ADDRESS command. Refer to [Changing the GPIB address](#), in [Chapter 2](#), for a procedure on how to change the GPIB address. The multimeter leaves the factory with the address set to decimal 22. The corresponding ASCII code is a listen address of 6 and a talk address of V.

NOTE

The examples in this manual are intended for Hewlett-Packard Series 200\300 computers using the BASIC language. They assume a GPIB interface select code of 7 and a device address of 22 resulting in a combined GPIB address of 722.

Mounting the multimeter

The multimeter comes equipped with four feet, which allow it to be used as a bench instrument. It also has two tilt stands that allow you to elevate the front of the multimeter. The multimeter can be mounted in a standard 19-inch rack using the optional rack mount kits listed in [Table 1-1](#).

Installation verification

The following program verifies that the multimeter is operating and can communicate with the controller over the GPIB bus.

```
10 PRINTER IS 1
20 OUTPUT 722;"ID?"
30 ENTER 722; IDENT$
40 PRINT IDENT$
50 END
```

If the multimeter has been correctly installed, the message **Keysight 3458A** will be printed on the designated system printer. If no message is printed, make sure power is applied to the multimeter. Also check the GPIB connections, the interface address setting, and the multimeter's address.

Maintenance

This section describes how to replace the multimeter's fuses and how to obtain repair service.

Replacing the line power fuse

The line power fuse holder is located on the right side of the multimeter's rear panel. Before replacing the fuse, disconnect the multimeter's line power. To replace the fuse, use a small flatblade screwdriver to push in on the fuse cap and rotate it counterclockwise. Remove the fuse cap and replace the fuse with the appropriate type (see [Table 1-4](#)). (The Keysight part number for the gray line power fuse cap is 2110-0565.) Re-install the fuse cap and apply power.

Table 1-4 Replacement power line fuses and caps

Line voltage	Power line fuse
100 or 120 VAC (Nominal)	1.5 A NTD, Keysight Part Number 2110-0043
220 or 240 VAC (Nominal)	500 mA SB, Keysight Part Number 2110-0202

Replacing a current fuse

Each of the front and rear current terminals (labeled I) contains a current fuse. To access the fuse, unscrew (rotate counterclockwise) the current terminal binding post knob until it stops. Push in on the terminal and rotate it clockwise. The entire terminal/fuse assembly can now be removed as shown in [Figure 1-5](#). If necessary, replace the fuse with a 1 A 250 V NTD fuse (Keysight part number 2110-0001). (CAUTION: never use a slow-blow fuse as a current fuse; multimeter damage will result.) Replace the terminal/fuse assembly by pushing it in and turning counterclockwise until the assembly locks in place.

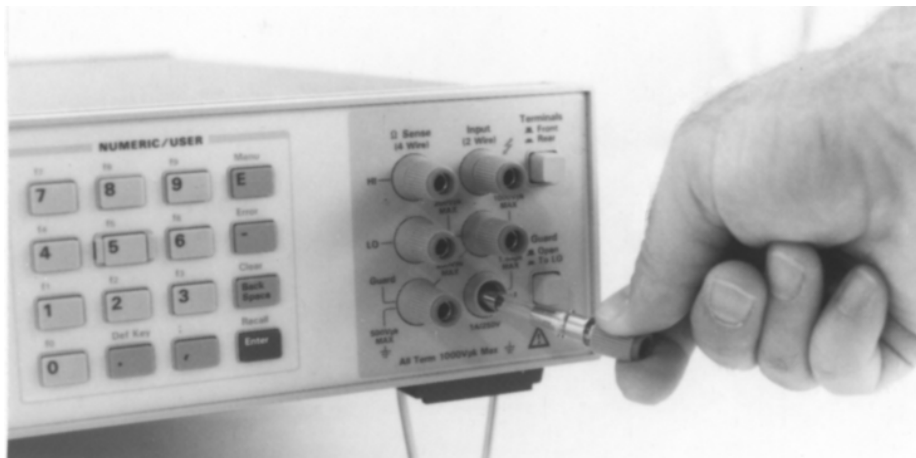


Figure 1-5 Current terminal/fuse assembly

Repair service

You may have the multimeter repaired at an Keysight Technologies service center whether it is under warranty or not. Contact the nearest Keysight Sales Office for shipping instructions prior to returning the instrument.

Serial number

Keysight instruments are identified by a two part, ten-character serial number of the form 0000A00000. The first four digits are the same for all identical products. They change only when a change is made to the product. The letter indicates the country of origin. An A indicates the product was made in the United States of America. The last five digits are unique to each instrument. The multimeter's serial number is located to the right of the multimeter's rear terminals.

Shipping instructions

If you need to ship the multimeter, be certain that the multimeter is in a protective package (use the original shipping containers and cushioning materials) to prevent transit damage. Such damage is not covered by warranty. Attach a tag to the shipment identifying the owner and indicating the service or repair needed. Include the model number and serial number of the multimeter. We suggest that you insure the shipment.

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2 Getting Started

Introduction	44
Before Applying Power	45
Applying Power	46
Operating from the front panel	49
Operating from Remote	70

Introduction

This chapter is intended for the novice multimeter user. It shows you how to use the multimeter's front panel, how to send commands to the multimeter from remote, and how to retrieve data from remote. Since front panel operation is discussed first, it covers important topics such as the power-on state, display annunciators, the various ways to select or enter parameters, and how to make a simple DC voltage measurement. For this reason, you should read the entire chapter even if you intend to use the multimeter primarily from remote.

Before Applying Power

- Make sure the line voltage selection switches on the multimeter's rear panel are set to match the local line voltage.
- Make sure the proper line fuse is installed.

If you have any questions concerning installation or power requirements, refer to [Chapter 1](#).

Applying Power

To turn on the multimeter, depress the front panel Power switch. If the multimeter does not appear to turn on, verify that the multimeter is connected to line power. If line power is not the problem, remove the power cord and check the line power fuse and the line voltage selection switch settings.

Power-on self-test

When power is applied, the multimeter performs a limited power-on self-test. This test verifies that the multimeter is operating but does not necessarily verify that measurements will be accurate.

Power-on state

When the power-on self-test is finished, the multimeter beeps once, automatically triggers, automatically selects the range, and performs DC voltage measurements. Also, the multimeter has set many of its commands to predefined power-on values as shown in [Table 2-1](#), This is called the power-on state.

Table 2-1 Power-on state

Command	Description
ACBAND 20, 2E6	AC bandwidth 20 Hz - 2 MHz
AZERO ON	Autozero enabled
DCV AUTO	DC voltage, autorange
DEFEAT OFF	Defeat disabled
DELAY -1	Default delay
DISP ON	Display Enabled
EMASK 32767	Enable all error conditions
END OFF	Disable GPIB EOI function
EXTOUT ICOMP, NEG	Input complete EXTOUT signal, negative pulse
FIXEDZ OFF	Disable fixed input resistance
FSOURCE ACV	Frequency and period source is AC voltage

Table 2-1 Power-on state (continued)

Command	Description
INBUF OFF	Disable input buffer
LEVEL 0, AC	Level trigger at 0%, AC-coupled
LFILTER OFF	Level filter disabled
LFREQ 50 or 60	Measured line frequency rounded to 50 or 60 Hz
LOCK OFF	Keyboard enabled
MATH OFF	Disable real-time math
MEM OFF	Disable reading memory (last memory operation = FIFO)
MFORMAT SREAL	Single real reading memory format
MMATH OFF	Disable post-process math
NDIG 7	Display 7.5 digits
NPLC 10	10 power line cycles of integration time
NRDGS 1, AUTO	1 reading per trigger, auto sample event
OCOMP OFF	Disable offset compensated resistance
OFORMAT ASCII	ASCII output format
QFORMAT NORM	Normal query format
RATIO OFF	Disable ratio measurements
RQS 0 (or 8)	0 disables status register conditions (if power-on SRQ was on when power was removed, value = 8).
SETACV ANA	Analog AC voltage mode
SLOPE POS	Positive slope for level triggering
SSRC LEVEL, AUTO	Level sync source event, auto synchronous AC voltage
SWEEP IOOE-9,1024	Sample interval 100 nanoseconds, 1024 samples
TARM AUTO	Auto trigger arm event
TBUFF OFF	Disable external trigger buffering
TIMER 1	1 second timer interval

Table 2-1 Power-on state (continued)

Command	Description
TRIG AUTO	Auto trigger event
DEGREE = 20 REF = 1 SCALE = 1 RES = 50 PERC = 1	

The display

In the power-on state, the display is continuously updated with each new DC voltage reading. Along the bottom of the display are a series of annunciators. These annunciators alert you to a variety of conditions. For example, the **SMPL** annunciator flashes whenever the multimeter has completed a reading. [Table 2-2](#) describes the meaning of each display annunciator.

Table 2-2 Display annunciators

Display annunciator	Description
SMPL	Flashes whenever a reading is completed
REM	The multimeter is in the GPIB remote mode
SRQ	The multimeter has generated a GPIB service request
TALK	The multimeter is addressed to talk on GPIB
LSTN	The multimeter is addressed to listen on GPIB
AZERO OFF	Autozero is disabled
MRNG	Autorange is disabled (the multimeter is using a fixed range)
MATH	One or two real-time or post-process math operations enabled
ERR	An error has been detected
SHIFT	The shift key has been pressed
MORE INFO	More information concerning the present configuration is available (use the right arrow key to view the information)

NOTE

If the **ERR** annunciator is illuminated at this point, an error was detected during or after the power-on self-test. You will learn how to determine the error later in this chapter in [Reading the error register](#).

Operating from the front panel

This section shows you how to make a simple DC voltage measurement, how to use the various front panel keys, and describes the multimeter functions important to front panel operation. **Figure 2-1** shows the multimeter's front panel features.

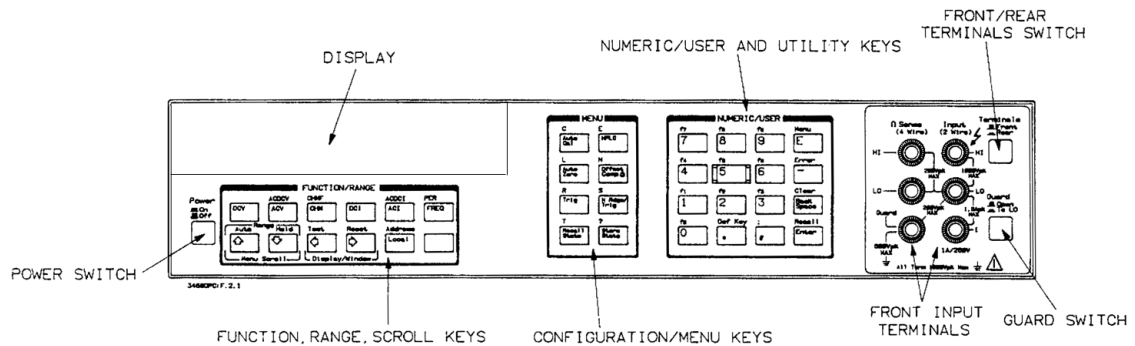


Figure 2-1 Front panel

Making a measurement

In the power-on state, DC voltage measurements are selected and the multimeter automatically triggers and selects the range. In the power-on state, you can make DC voltage measurements simply by connecting a DC voltage to the input terminals as shown in [Figure 2-2](#). The connections shown in [Figure 2-2](#) also apply for AC voltage, 2-wire resistance, AC+DC voltage, digitizing, and frequency or period measurements from a voltage input source. Refer to [Chapter 3](#) for a CAUTION concerning the multimeter's maximum input voltage and current.

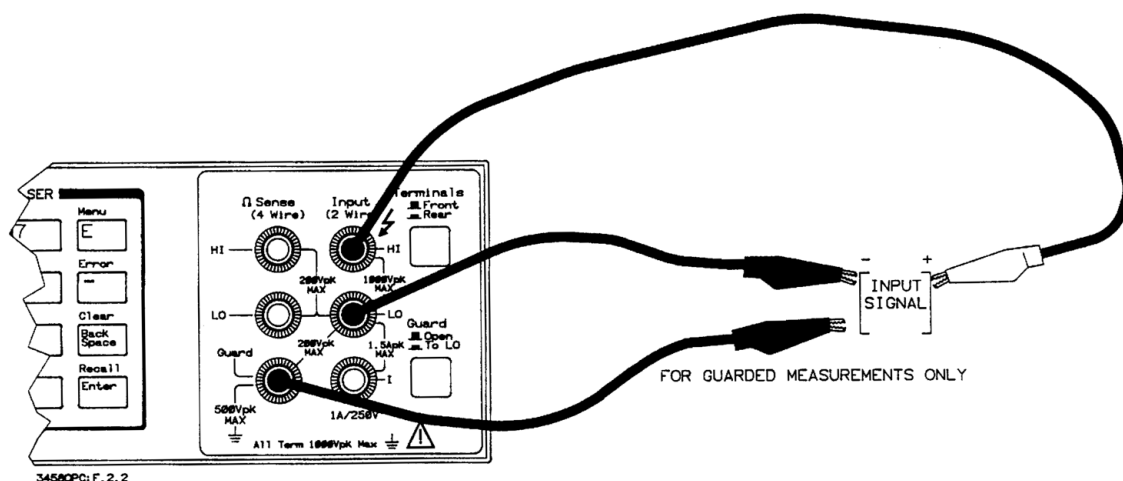


Figure 2-2 Standard 2-wire (plus guard) measurements

Changing the measurement function

The row of keys located directly under the display (**FUNCTION** keys) select the multimeter's standard measurement functions. **Figure 2-3** shows the **FUNCTION** keys and the measurement function selected by each.

Key	Description
DCV	DC voltage measurements
ACV	AC voltage measurements
OHM	2-wire resistance measurements
DCI	DC current measurements
ACI	AC current measurements
FREQ	Frequency measurements
 	AC+DC voltage measurements
 	4-wire resistance measurements
 	AC+DC current measurements
 	Period measurements

Figure 2-3 Function keys

In addition to the functions selected by the **FUNCTION** keys, the multimeter can perform direct-sampled or sub-sampled digitizing, ratio measurements, and AC or AC+DC voltage measurements using the synchronous or random measurement methods. These functions can be selected from the front panel by accessing the appropriate command(s) using the alphabetic menu keys (these keys are

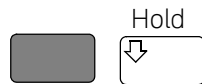
discussed later in this section under [Using the MENU keys](#)). For more information on any measurement function or method, refer to [Chapter 1](#).

Autorange and manual ranging

In the power-on state, the multimeter automatically selects the appropriate measurement range. This is called autorange. In many cases, you will probably want to continue using autorange. However, you have two other ranging choices: hold and manual ranging.

Hold

This choice allows you to shut off autoranging. To do this, let autorange choose a range and then press:



NOTE

When you press the blue shift key, the display's **SHIFT** annunciator illuminates. The shifted keyboard functions are printed in blue above the keys.

Notice the display's **MRNG** (manual range) annunciator is on. This annunciator is on whenever you are not using autorange.

Manual ranging

The second choice lets you manually select the range. When the multimeter is in the measurement mode (that is, the multimeter is making and displaying measurements or the display is showing OVLD) you can change the range by pressing the up or down arrow keys. To go to a higher range, press:

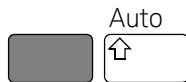


By repeatedly pressing the up arrow key, you can increment up to the highest range. When you reach the highest range, pressing the up arrow key no longer

changes the range. To go to a lower range, press:



By repeatedly pressing the down arrow key, you can decrement down to the lowest range. When you reach the lowest range, pressing the down arrow key no longer changes the range. To return to autoranging, press:



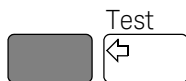
Self-test

When you applied power to the multimeter, it automatically performed a limited power-on self-test. Before you start making measurements, however, you may want to have more confidence that the multimeter is fully operational. This is the job of the self-test. The self-test performs a series of tests that check the multimeter's operability and accuracy.

NOTE

Always disconnect any input signals before you run self-test. If you leave an input signal connected to the multimeter, it cause a self-test failure.

The self-test takes over 50 seconds. To run self-test press:



If the self-test passed, the display shows:

SELFTEST PASSED

When self-test passes, you have a high confidence that the multimeter is operational and, assuming proper calibration and autocalibration, that measurements will be accurate.

If any of the tests failed, the **ERR** annunciator illuminates and the display shows:

SELFTEST FAILED

If the self-test failed, one or more error conditions have been detected. Refer to the next section [Reading the error register](#).

Reading the error register

Whenever the display's **ERR** annunciator is illuminated, one or more errors have been detected. A record of hardware errors is stored in the auxiliary error register. A record of programming and syntax errors is stored in the error register. To read the error record(s), press:



The lowest numbered error and a description of the error is displayed. For example, a possible error message is:

**209, "HARDWARE FAILURE—
INTERNAL OVERLOAD: 101"**

Use the right arrow key to view the entire message. When the error message has a 100-series numeric prefix (e.g., 105), it indicates a programming or syntax error. A 200-series prefix (e.g., 209) indicates a hardware error.

NOTE

When you get a hardware error (200-series prefix), run the self-test again. If you repeatedly get the error, the multimeter may need repair.

If the **ERR** annunciator is still illuminated, more errors have been recorded. Repeat the above key sequence until all errors have been read and the **ERR** annunciator is no longer illuminated. When you have read all the errors, the error annunciator goes off. If you try to read another error, the display shows:

0, NO "ERROR"

You do not have to run self-test to get an error. The multimeter detects errors that occur while entering data, when changing functions or ranges, and so on. The multimeter beeps whenever it detects an error.

Whenever you want to clear information (such as an error description) from the display and return it to displaying measurements, press:



NOTE

You can also clear the display by repeatedly pressing the **Back Space** key (unshifted).

Resetting the multimeter

Many times during operation, you may wish to return to the power-on state. The front panel **Reset** key returns you to the power-on state without having to cycle the multimeter's power. To reset the multimeter, press:



The multimeter begins the reset process with a display test which illuminates all display elements including the annunciators as shown in [Figure 2-4](#). (By holding down the **Reset** key, the multimeter continuously performs its display test).

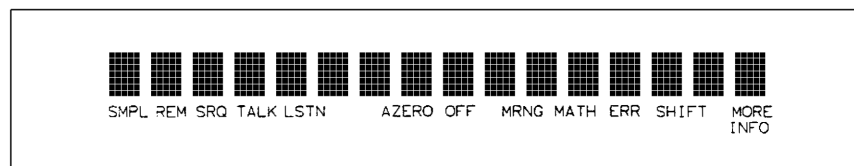


Figure 2-4 Display test

CAUTION

Pressing the shifted front panel **Reset** key performs the power-on sequence which has the same effect as cycling the multimeter's power. This destroys any stored reading and compressed subprograms, sets the power-on SRQ bit in the status register (these functions are discussed later in this manual), resets the A/D converter reference frequency and performs the power-on self test. Executing the RESET command from the alphabetic command menu (**MENU** keys) returns the multimeter to the power-on state but does not perform the power-on sequence. The **MENU** keys are discussed later in this chapter.

Using the configuration keys

The configuration keys (unshifted **MENU** keys) let you rapidly access the most frequently used multimeter features. [Figure 2-5](#) shows each key, the corresponding multimeter command, and the function of each. (These functions are discussed in detail in [Chapter 3](#) and [Chapter 4](#).)

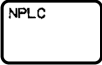
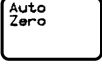
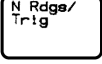
Key	Command	Description
	ACAL	Performs one or all autocal routines (It takes over 11 minutes to run all of the autocal routines. Never reset the multimeter to abort an autocal. Once you start an autocal you must complete it).
	NPLC	Sets integration time in terms of power line cycles
	AZERO	Enables or disables the autozero function
	OCOMP	Enables or disables offset compensation for 2- or 4-wire resistance measurements
	TRIG	Specifies the trigger event
	NRDGS	Selects the number of readings per trigger event and the sample event
	RSTATE	Recalls a previously stored state from memory
	SSTATE	Stores the multimeter's present state in memory

Figure 2-5 Configuration key functions

We will use the **Trig** key to demonstrate how to use the configuration keys. Press:



The display shows:

TRIG ■■

This is the command header for the trigger command. Notice the multimeter automatically placed a space after the command header.

Selecting a parameter

For parameters that have a list of choices (non-numeric parameters), you can use the up and down arrow keys to review the choices. Press:



The display shows:

TRIG LEVEL ■■

Press:



The display shows:

TRIG AUTO ■■

When using the up or down arrow keys, if you step past the last parameter choice, a wraparound occurs to the other end of the menu. Suppose you want to suspend triggering. Press the up or down arrow key until the display shows:

TRIG HOLD ■■

Press:



You have now changed the trigger event from auto (power-on state) to HOLD which causes the multimeter to stop taking readings. (Triggering is discussed in detail in [Chapter 4](#).)

Default values

Most parameters have a default value. A default value is the value selected when you execute a command but do not specify a value. For example, the default value for the trigger parameter is SGL. Press:

Trig

TRIG

Press:

Enter

Notice that the multimeter takes one reading and then stops (after the single trigger, the trigger event becomes HOLD regardless of the previously specified trigger event). You can also enter -1 to select the default value. Press:

Enter - 1 Enter

The multimeter again takes a single reading and then stops.

Numeric parameters

Some commands use numeric parameters. A numeric parameter is the actual value used by the multimeter. We will use the NPLC configuration key to demonstrate numeric parameters. Press:

NPLC

This display shows:

NPLC

Notice that if you press the up or down arrow key, no parameter choice is displayed. This means there is no menu and you must enter a number. For example, press:



You have now selected 1 power line cycle of integration time for the A/D converter. Integration time is the actual time that the A/D converter measures the input signal. (Integration time is discussed in detail in [Chapter 3](#).)

Exponential parameters

You can also enter numeric parameters using exponential notation. For example, press:



You have now selected 0.1 power line cycles of integration time. At this point, you should reset the multimeter to return the number of power line cycles to 10 by pressing:



Multiple parameters

Many commands have more than one parameter. (Multiple parameters are separated by commas.) We will use the NRDGS command, which has two parameters, as an example of a command with multiple parameters. Press:

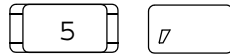


The display shows:

NRDGS 

The first parameter in the NRDGS command is a numeric parameter that specifies the number of readings made per trigger event. For example, to specify 5 readings

per trigger event, press:



The display shows:

NRDGS 5, ■■■

The second parameter of the NRDGS command specifies the event that initiates each reading. Since this is not a numeric parameter, a menu is available for this parameter. Use the up or down arrow keys to cycle through the list of choices. When the display shows:

NRDGS 5, AUTO ■■■

Execute the command by pressing:



You have now selected five readings per trigger event. If you execute the TRIG SGL command, for example, the multimeter will take five readings and then stop. (The NRDGS command is discussed in detail in [Chapter 4](#).)

Using the MENU keys

In addition to the configuration keys, the multimeter has an alphabetic command menu that can be accessed using the shifted **MENU** keys labeled C, E, L, N, R, S, and T. Each of these letters corresponds to the area you will enter into the command menu. For example, to enter the menu with commands starting with T, press:



The display shows:

TARM ■■■

You can now use the **Menu Scroll** keys (up or down arrow keys) to step through the menu in alphabetical order (down arrow key) or in reverse alphabetical order (up arrow key). For example, starting with the TARM display shown above, by pressing the down arrow key once, the display shows the next command in alphabetical order (TBUFF). (You can also press and hold the up or down arrow key to rapidly step through the menu.) Once you have found the desired command, you can press the **Enter** key to execute it immediately (using default parameter values if applicable). If you need to specify command parameter(s), with the command displayed, press the right arrow key or the comma key (or, if the first parameter is numeric, a numeric key). This selects the command and allows you to specify or select parameter(s) using the procedures described earlier in this section.

There are two alphabetic menus available: FULL and SHORT. You can select between these menus using the shifted **Menu** key. The specified menu choice is stored in continuous memory (not lost when power is removed). The FULL menu contains all commands except query commands that can be constructed by appending a question mark to a command (e.g., BEEP, BEEP?). (Query commands are discussed next.) The SHORT menu eliminates the GPIB bus-related commands, commands that are seldom used from the front panel, and any commands that have dedicated front panel keys (e.g., the **NPLC** key or the **Trig** key).

Query commands

There are a number of commands in the alphabetic command directory that end with a question mark. These commands are called query commands since each returns a response to a particular question. For example, access the LINE? query command from the command menu and press the **Enter** key. The multimeter responds to this query command by measuring and displaying the power line frequency. (Use the right arrow key to view the entire response.) As another example, access the TEMP? command from the command menu and press Enter. This command returns the multimeter's internal temperature in degrees Centigrade.

Standard queries

The FULL command menu contains the following standard query commands:

AUXERR?MCOUNT?

CAL?MSIZE?

CALNUM?OPT?
 ERR?REV?
 ERRSTR?SSPARM?
 ID?STB?
 ISCALE?TEMP?
 LINE?

Additional queries

In addition to the queries listed above, you can create others by appending a question mark to any command that can be used to program the multimeter. For example, the AZERO command (**Auto Zero** configuration key) enables or disables the autozero function. You can determine the present autozero mode by appending a question mark to the AZERO command. To do this, press:



The multimeter responds by displaying the present autozero mode (power-on mode = ON). (Notice that this command is immediately executed; you do not have to press the **Enter** key.)

NOTE

The QFORMAT command can be used to specify whether query responses will be numeric, alpha, or a combination of alpha and numeric. Refer to the QFORMAT command, in [Chapter 6](#), for more information.

Display control

The shifted **Clear** key, the **Back Space** key, and the **Display/Window** keys (left and right arrow keys) allow you to control the display.

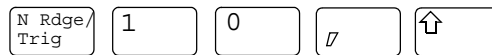
Clearing the display

Whenever you want to clear information (such as a query response) from the display, press:



Display editing

The **Back Space** key allows you to edit parts of a command string while entering the string or when the string is recalled (discussed later). For alpha parameters or command headers, pressing the **Back Space** key once erases the entire parameter or header. For commas, spaces, and numeric parameters, only one character is erased each time you press Back Space. For example, press:



The display shows:

NRDGS 10, LINE ■■

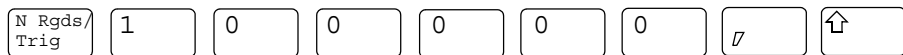
By pressing the **Back Space** key once, the entire second parameter (LINE) is erased. The display shows:

NRDGS 10, ■■

Now by pressing Back Space once, the comma is erased. Pressing Back Space two more times erases both numeric characters (10). At this point, you can reenter the first parameter using the numeric keypad and the second parameter using the **Menu Scroll** keys. Press the **Enter** key to execute the edited command.

Viewing long displays

When entering commands containing more than 16 characters, the previously entered characters are scrolled off the left side of the display to make room for those being entered. The **Display/Window** keys (left and right arrow keys) allow you to view the entire line by scrolling it left or right. The **Display/Window** keys can also be used to view long strings such as error messages, the calibration string (CALSTR? command), and user-defined key definitions (discussed later). For example, press:



The display shows:

DGS 100000. LINE

By pressing the left arrow key, you can view the first part of the command while scrolling the last part off the right side of the display. Now, by pressing the right arrow key, you can view the last part of the command and scroll the first part off the left side of the display.

NOTE

Think of the display as a window you can move to the left or right using the arrow keys.

MORE INFO display

In addition to scrolling the display left and right, the **Display/Window** keys allow you to view additional display information when the display's **MORE INFO** annunciator is illuminated. For example, access and execute the SETACV RNDM command from the alphabetic command menu. Now press the front panel **ACV** key. Notice that the multimeter's **MORE INFO** annunciator is illuminated. This means there is more information available than is being displayed. Press:

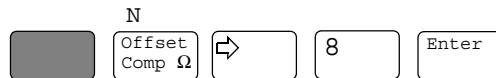


The present AC voltage measurement method (SETACV RNDM) is displayed. At this point, reset the multimeter to return it to the power-on state by pressing:



Digits displayed

When the multimeter is displaying readings, you can vary the number of digits it displays. In the power-on state, the display is showing 7.5 digits although the multimeter is resolving 8.5 digits. To display all 8.5 digits, press:



NOTE

The display's leftmost digit (referred to as a 1/2 digit) is implied when you are specifying display digits.

The NDIG command only masks digits from the display. It does not affect readings sent to reading memory or transferred over the GPIB bus. Also, you cannot view more digits than are being resolved by the multimeter.

Recall

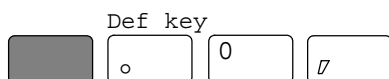
You can easily recall the last executed command without repeating the command entry process. Press:



The display will show the last command executed. (You cannot recall commands that are executed immediately such as Reset or DCV, or any command that contained the calibration security code.) By repeating the above keystrokes, you can recall previously executed commands. After recalling the desired command, you can modify it (see [Display editing](#) earlier in this section) and execute it by pressing Enter.

User-defined keys

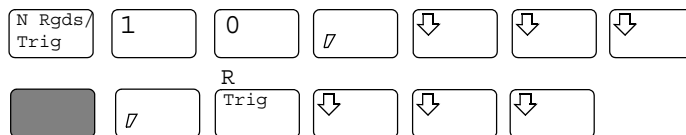
You can assign a string of one or more commands to each of the **USER** keys labeled **f0** - **f9**. After assigning a string to one of these keys (maximum string length is 40 characters), pressing that key displays the string on the display. You can then execute the string by pressing the **Enter** key. The **Def** key allows you to assign a command string to any of the user-defined keys. For example, to assign the commands `NRDGS 10,AUTO; TRIG SGL` (the semicolon links multiple commands) to the user-defined key **f0**, press:



The display shows:

DEFKEY 0, "

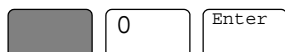
You can now enter the command string by pressing:



To store the string (this does not execute the string, it merely assigns it to the user-defined key), press:



To access and execute the string assigned to key **f0**, press:



The multimeter will take 10 readings and then stop.

As a special keyboard feature, you can access the string assigned to a key without pressing the shift key (except when you are in the process of entering a

command). For example, you can access and execute the string assigned to key **f0** by pressing:



You can also assign commands from the command menu to user-defined keys. You cannot assign a command using an immediate execute key (DCV, ACV, etc.) Instead, you must access that command from the menu. Key definitions stored from the front panel can be edited from the front panel. (You cannot edit a key definition that was downloaded from the controller.) Editing is done by pressing the user-defined key and, while the string is displayed, editing the string as described under **Display editing** earlier in this section. After editing the string, press the **Enter** key to execute the string. (The previous string is still assigned to the user-defined key.) An edited string cannot be re-assigned to a user-defined key. If you want to change a key definition, you must repeat the above steps.

Installing the keyboard overlay

Figure 2-6 shows the keyboard over-lay that fits over the **USER** keys. You can write on this overlay with a pencil to identify the command(s) assigned to each user-defined key.

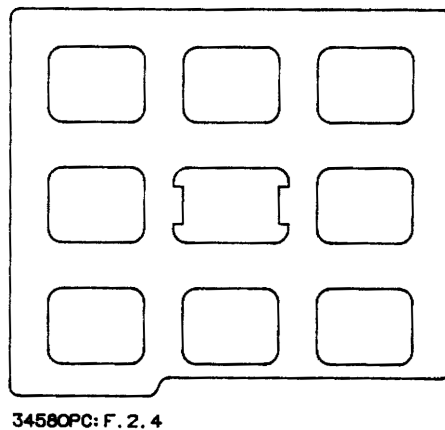


Figure 2-6 Keyboard overlay (Keysight part number 03458A-84303)

The overlay is held in place by two tabs that secure it to the collar around numeric key **5**. To install the overlay, insert the overlay's left tab into the left side of the collar. Bend the overlay as shown in [Figure 2-7](#) and press the right tab into the collar.



Figure 2-7 Installing the keyboard overlay

Operating from Remote

This section shows you the fundamentals of operating the multimeter from remote. This includes reading and changing the GPIB address, sending a command to the multimeter, and retrieving data from the multimeter.

Input/Output statements

The statements used to operate the multimeter from remote depend on the computer and its language. In particular, you need to know the statements the computer uses to input and output information. For example, the input statements for the Hewlett-Packard Series 200/300 BASIC language are:

ENTER or TRANSFER

The output statement is:

OUTPUT

Read your computer manuals to find out which statements you need to use. The examples in this manual use Hewlett-Packard Series 200/300 BASIC language.

Reading the GPIB address

Before you can operate the multimeter from remote, you need to know its GPIB address (factory setting = 22). To check the address, press:



A typical display is:

ADDRESS 22 ■■■

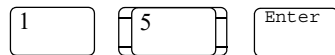
The displayed response is the device address. When sending a remote command, you append this address to the GPIB interface's select code (normally 7). For example, if the select code is 7 and the device address is 22, the combination is 722.

Changing the GPIB address

Every device on the GPIB bus must have a unique address. If you need to change the multimeter's address, access the ADDRESS command from the command menu (**MENU** keys), with the display showing:

ADDRESS 

You can enter the new address. For example, press:



You have now changed the address to 15. If you want to change the address back to 22, repeat the above procedure (or use the **Recall** key) and specify 22 instead of 15.

Sending a remote command

To send the multimeter a remote command, combine the computer's output statement with the GPIB select code, the device address, and finally, the multimeter command. For example, to make the multimeter beep, send:

OUTPUT 722; "BEEP"

Notice the display's REM and LSTN annunciators are illuminated. This means the multimeter is in the remote mode and has been addressed to listen (receive a command).

Getting data from the multimeter

The multimeter is capable of outputting readings and responses to query commands. As an example, have the multimeter generate a response to a query command by sending:

OUTPUT 722; "ID?"

When you send a query from remote, the multimeter does not display the response as it did when you executed the command from its front panel. Instead, the multimeter sends the response to its output buffer. The output buffer is a register that holds a query response or a single reading until it is read by the

computer or replaced by new information. Use the computer's input statement to get the response from the output buffer. For example, the following program reads the response (Keysight 3458A) and prints it.

```
10 ENTER 722;A$  
20 PRINT A$  
30 END
```

The same technique allows you to get readings from the multimeter. Whenever the multimeter is making measurements and you have not enabled reading memory (reading memory is discussed in [Chapter 4](#)), you can get a reading by running the following program.

```
10 ENTER 722;A  
20 PRINT A  
30 END
```

The Local key

When you press a key on the multimeter's keyboard while operating from remote, the multimeter does not respond. This is because the multimeter is in the remote mode (as indicated by the display's **REM** annunciator) and is ignoring all but the **Local** key. To return the multimeter to local mode, press:



3

Configuring for Measurements

Introduction	74
General Configuration	75
Configuring for DC or Resistance Measurements	86
Configuring for AC Measurements	98
Configuring for Ratio Measurements	109
Using Subprogram Memory	111
Using State Memory	116
Using the Input Buffer	118
Using the Status Register	119

Introduction

This chapter shows how to configure the multimeter for all types of measurements except digitizing.^[1] This chapter also shows you how to use subprogram and state memory, the input buffer, and the status register. After using this chapter to configure the multimeter for your application, you can then use [Chapter 4](#) to learn how to trigger readings and transfer them to reading memory or the GBIB output buffer. The major sections in this chapter are:

- General Configuration
- Configuring for DC or Resistance Measurements
- Configuring for AC Measurements
- Configuring for Ratio Measurements
- Using Subprogram Memory
- Using State Memory
- Using the Input Buffer
- Using the Status Register

[1] This chapter doesn't address digitizing specifically although most of the information under [General Configuration](#) does apply to digitizing. Refer to [Chapter 5](#) for specific information on digitizing.

General Configuration

This section discusses the multimeter's self-test, calibration requirements, and general configuration topics that apply to many or all measurement functions.

Self-test

Prior to configuring for measurements, you should run the self-test to ensure the multimeter is operational. The self-test takes approximately 50 seconds to complete. To run self-test, send:

OUTPUT 722;"TEST"

If self-test passes, you have a high confidence level that the multimeter is operational and, assuming proper calibration, that measurements will be accurate. If one or more tests fail, the multimeter sets bit(s) in the auxiliary error register, which also sets bit 0 in the error register, and the display's **ERR** annunciator illuminates.

Reading the error registers

When a hardware error is detected, the multimeter sets a bit in the auxiliary, error register and also sets bit 0 in the error register. When a programming error is detected, the multimeter sets a bit in the error register only.

The ERRSTR? command reads each error (one error at a time) and then clears the corresponding bit. If one or more bits are set in the auxiliary error register, the ERRSTR? command reads that register first before proceeding to the error register. The ERRSTR? command returns two responses. The first response is the decimal: value of the least significant (lowest numbered) set bit. The second response is a message (string) explaining the error (the maximum string length returned is 200 characters). After reading a bit, the ERRSTR? command clears that bit.

The following program uses the ERRSTR? command to read all errors, one error at a time. After all set bits have been read and cleared, or if there were no set bits in either register, the ERRSTR? command returns 0, "NO ERROR".

10 OPTION BASE 1

!COMPUTER ARRAY NUMBERING STARTS WITH 1

20 DIM A\$(200)

```

!DIMENSION STRING VARIABLE
30 OUTPUT 722; "ERRSTR?"
!READS ERROR MESSAGE
40 ENTER 722; A,A$
!ENTERS NUMERIC INTO A, STRING INTO A$
50 PRINT A,A$
!PRINTS RESPONSES
60 IF A>0 THEN GOTO 30
!LOOP TO READ EACH ERROR
70 END

```

The ERR? and AUXERR? commands return the decimal sum of all set bits in the error register and the auxiliary error register, respectively. Refer to these commands in [Chapter 6](#) for example programs and listings of the possible errors.

Calibration

The multimeter has two forms of calibration: external calibration and autocalibration. The external calibration involves a procedure using external reference sources. Refer to the *3458A Calibration Manual* for more information on the external calibration.

The CALNUM? query command returns a number indicating the number of times the multimeter has been externally calibrated. By routinely checking this number, you can monitor the calibrations performed on the multimeter. The following program reads and returns the present calibration number.

```

10 OUTPUT 722;"CALNUM?"
20 ENTER 722;A
30 PRINT A
40 END

```


Autocalibration

The multimeter has four autocalibration (autocal) routines: DCV, AC, OHMS, and ALL. These routines improve short-term accuracy for many or all measurement functions, but are not substitutes for periodic external calibration of the multimeter. The measurement functions affected by each routine are:

- The DCV routine enhances all measurement functions. This routine takes about 1 minute to perform.
- The AC routine performs specific enhancements for AC or AC+DC voltage (all measurement methods), AC or AC+DC current, direct- or sub-sampled digitizing (AC- or DC-coupled), frequency, and period measurements. The AC routine takes about 1 minute to perform.
- The OHMS routine performs specific enhancements for 2 or 4-wire ohms, DC current, and AC current measurements. The OHMS routine takes about 10 minutes to perform.
- The ALL routine enhances all measurement functions by performing all of the above routines. The ALL routine takes about 11 minutes to perform.

NOTE

You should not cycle power or reset the multimeter while an autocal routine is being performed. If you do, the multimeter generates the ACAL REQUIRED error (since many or all of its autocal constants have been erased). You must then perform the ALL routine to eliminate the error.

Since the DCV routine applies to all measurement functions, you should perform the DCV autocal before performing the AC or OHMS autocal, or perform ALL of the routines (see second example below).

Running autocal

Suppose you intend to make 4-wire ohms measurements. The DCV autocal routine increases the short term accuracy for all measurements and the OHMS autocal enhances resistance measurements (and current measurements). The following program performs the DCV autocal followed by the OHMS autocal.

```
10 OUTPUT 722; "ACAL DCV"
20 OUTPUT 722; "ACAL OHMS"
30 END
```

If autocal is secured (it is not secured when shipped from the factory), you must enter the security code to perform autocal; refer to the ACAL command in [Chapter 6](#) for more information. You can perform all of the autocal routines (DCV first, followed by OHMS and AC) by sending:

OUTPUT 722; "ACAL ALL"

Always disconnect any input signals before performing autocal. If you leave an input signal connected to the multimeter, it may adversely affect the autocal and subsequent measurements.

When to use autocal

For maximum accuracy, we recommend performing ACAL ALL once every 24 hours or when the multimeter's temperature changes by ± 1 °C from when it was last externally calibrated or from the last autocal. (We recommend that the calibrator store the multimeter's internal calibration temperature using the CALSTR command; this can be read later using the CALSTR? command.) The following example shows how to use the TEMP? command to monitor the multimeter's internal temperature (in degrees Celsius).

10 OUTPUT 722; "TEMP?"

20 ENTER 722;A

30 PRINT A

40 END

The autocal constants are stored in continuous memory (they remain intact when power is removed). Therefore, it is not necessary to perform autocal simply because power has been cycled.

Selecting the input terminals

The multimeter has both front and rear terminals for measurement connections. The front panel Terminals switch allows you to select between the two (depressed = Rear, out = Front). You cannot select the input terminals from remote. The measurement connection illustrations in this chapter show the front terminal connections only. For rear terminal connections, connect each wire to the similarly labeled rear terminal. We recommend high impedance, low dielectric absorption cables for all measurement connections.

WARNING

- Only qualified, service trained personnel who are aware of the hazards involved should remove or install the multimeter or connect wiring to the multimeter. Disconnect the multimeter's power cord before removing any covers, changing the line voltage selector switches, or installing or changing the line power fuse.
 - Measuring high voltage is always hazardous. All multimeter input terminals (both front and rear) must be considered as hazardous whenever inputs in excess of 42 V are connected to any terminal. Regard all terminals as being at the same potential as the highest voltage applied to any terminal.
 - Keysight recommends that the wiring installer attach a label to any wiring having hazardous voltages. This label should be as close to the input terminals as possible and should be an eye catching color, such as red or yellow. Clearly indicate on the label that high voltages may be present.
-

CAUTION

The current input terminals (I) are rated at ± 1.5 A peak with a maximum non-destructive input of < 1.25 A RMS. Current inputs are fuse protected. The multimeter's input voltage ratings are:

Table 3-1 Input ratings

	Rated input	Maximum non-destructive input
HI to LO Input:	± 1000 V peak	± 1200 V peak
HI/LO Ω Sense to LO Input:	± 200 V peak	± 350 V peak
HI to LO Ω Sense Input:	± 200 V peak	± 350 V peak
LO Input to Guard:	± 200 V peak	± 350 V peak
Guard to Earth Ground:	± 500 V peak	± 1000 V peak
HI/LO Input, HI/LO Ω Sense, or I terminal to earth ground:	± 1000 V peak	± 1500 V peak
Front terminals to rear terminals:	± 1000 V peak	± 1500 V peak

The multimeter will be damaged if any of the above maximum non-destructive inputs are exceeded.

Guarding

The measurement connection illustrations in this chapter show the multimeter's Guard terminal connected to the low side of the measurement source (guarded measurements). This configuration provides maximum *effective common mode rejection* (ECMR) on the input terminals selected by the Terminals switch, assuming the Guard switch is in the Open (out) position. For non-guarded measurements, depress the Guard switch (TO LO position) and do not connect the Guard terminal to the measurement source. In the TO LO position, the Guard switch internally connects the Guard terminal to the LO Input terminal on the terminals selected by the Terminals switch. This configuration provides reduced ECMR. The specifications in [Appendix A](#) shows the ECMR for guarded measurements. We recommend high impedance, low dielectric absorption cables for all measurement connections.

Suspending readings

In the multimeter's power-on state, the trigger arm, trigger, and sample events are set to AUTO (these events are discussed in detail in [Chapter 4](#)). This causes the multimeter to continuously take readings. Prior to configuring the multimeter for measurements, you should suspend readings. Suspending readings decreases the amount of time required for configuration and prevents the possibility of undesired readings being placed in reading memory or the GPIB output buffer. You can suspend readings by presetting the multimeter (discussed next) or by setting the trigger arm or trigger event to HOLD as follows:

```
OUTPUT 722; "TARM HOLD"
```

or

```
OUTPUT 722; "TRIG HOLD"
```

After configuring the multimeter, you can enable measurements by changing the trigger arm or trigger event from HOLD to some other event. (Refer to [Chapter 2](#) for more information on triggering measurements).

Presetting the multimeter

The PRESET NORM command is similar to the RESET command but configures the multimeter to a good starting point for remote operation. (RESET is primarily for front panel use.) It's a good idea to execute PRESET NORM as the first step when configuring the multimeter since it sets the multimeter to a known configuration and suspends readings by setting the trigger event to synchronous (TRIG SYN) command. [Table 3-2](#) shows the commands executed by the PRESET NORM command.

Table 3-2 PRESET NORM state

Command	Description
ACBAND 20,2E+6	AC bandwidth 20 Hz - 2 MHz
AZERO ON	Autozero enabled
BEEP ON	Beeper enabled
DCV AUTO	DC voltage measurements, autorange
DELAY -1	Default delay

Table 3-2 PRESET NORM state (continued)

Command	Description
DISP ON	Display enabled
FIXEDZ OFF	Disable fixed input resistance
FSOURCE ACV	Frequency and period source is AC voltage
INBUF OFF	Disable input buffer
LOCK OFF	Keyboard enabled
MATH OFF	Disable real-time math
MEM OFF	Disable reading memory
MFORMAT SREAL	Single real reading memory format
MMATH OFF	Disable post-process math
NDIG 6	Display 6.5 digits
NPLC 1	1 power line cycle of integration time
NRDGS 1,AUTO	1 reading per trigger, auto sample event
OCOMP OFF	Disable offset compensated ohms
OFORMAT ASCII	ASCII output format
TARM AUTO	Auto trigger arm event
TIMER 1	1 second timer interval
TRIG SYN	Synchronous trigger event

All math registers set to 0 except:

DEGREE = 20

PERC = 1

REF = 1

RES = 50

SCALE = 1

When attempting to preset from remote, it is possible that the multimeter is busy or the GPIB interface is being held. In either case, the multimeter will not respond to a remote command. It's good practice to send the GPIB Device Clear command prior to presetting the multimeter. The multimeter responds immediately to the Device Clear command. The following program sends the Device Clear command followed by the PRESET NORM command:

```
10 CLEAR 722
20 OUTPUT 722;"PRESET NORM"
30 END
```

In addition to the PRESET NORM command, the multimeter has a PRESET FAST command (configures for fast readings and transfers), which is discussed in [Chapter 4](#), and a PRESET DIG command (configures for DCV digitizing) which is discussed in [Chapter 5](#).

Specifying a measurement function

The first parameter of the FUNC command selects the measurement function. For example, to specify DC voltage measurements, send:

```
OUTPUT 722;"FUNC DCV"
```

The FUNC command header is optional and can be omitted. For example, you can specify DC voltage measurements simply by sending:

```
OUTPUT 722;"DCV"
```

The remaining examples in this chapter use the shortened (no FUNC header) version. [Table 3-3](#) shows the various measurement function parameters and the function selected by each.

Table 3-3 Measurement function parameters

Function parameter	Description
ACDCI	Selects AC current measurements, DC coupled
ACDCV	Selects AC voltage measurements, DC coupled
ACI	Selects AC current measurements, AC coupled
ACV	Selects AC voltage measurements, AC coupled
DCI	Selects DC current measurements

Table 3-3 Measurement function parameters (continued)

Function parameter	Description
DCV	Selects DC voltage measurements
DSAC ^[a]	Direct sampling, AC coupled
DSDC ^[a]	Direct sampling, DC coupled
FREQ	Selects frequency measurements
OHM	Selects 2-wire ohms measurements
OHMF	Selects 4-wire ohms measurements
PER	Selects period measurements
SSAC ^[a]	Sub-sampling, AC coupled
SSDC ^[a]	Sub-sampling, DC coupled

[a] Refer to [Chapter 5, "Digitizing"](#) for more information on these functions.

Autorange

When the autorange function is enabled, the multimeter samples the input prior to each reading (when readings are being triggered) and automatically selects the correct range. Since autorange requires sampling the input, measurements made with autorange enabled take longer than measurements made on a fixed range. In the power-on/PRESET NORM state, autorange is enabled. If you intend to measure a fairly stable input signal, you can use the `ARANGE ONCE` command to allow autorange to select the correct range (when readings are triggered) and then disable autorange for subsequent readings. This allows you to get the automatic range selection advantage of autorange and also the speed advantage of readings made with autorange disabled. To do this, send:

OUTPUT 722; "ARANGE ONCE"

Now when triggering begins, the multimeter will select the correct range and then disable autorange. Later, if you need to enable autorange, send:

OUTPUT 722; "ARANGE ON"

Specifying the range

You specify a fixed range using the first parameter of one of the function commands (ACV, DCV, OHM. etc.) or the RANGE command. This parameter is called *max_input* since you specify it as the input signal's maximum expected amplitude (or the maximum resistance for resistance measurements). The multimeter then chooses the correct range. When specifying *max_input*, use the absolute value of the input signal—no negative numbers. For example, to specify DC voltage with a maximum input of 2.5 volts, send:

OUTPUT 722; "DCV 2.5"

In this case, the multimeter selects the 10 VDC range. To specify a different *max_input* (e.g. 15 V) without changing the measurement function, send:

OUTPUT 722; "RANGE 15"

In this case, the multimeter selects the 100 V range.

NOTE

For frequency and period measurements, the *max_input* parameter specifies the maximum amplitude of the input signal. It does not specify the frequency range (Hz) or the period range (seconds).

You select the autorange mode by defaulting the *max_input* parameter or by specifying AUTO. For example, to select, autorange using the DCV command, send:

OUTPUT 722; "DCV"

Refer to the FUNC or RANGE command in [Chapter 6](#) for tables showing the ranges for each measurement function.

Configuring for DC or Resistance Measurements

This section describes how to configure the multimeter for making DC voltage, DC current, and 2-wire or 4-wire resistance (ohms) measurements.

DC voltage

The multimeter measures DC voltage on any of five ranges. [Table 3-4](#) shows each DC voltage range and its full scale reading (which also shows the maximum number of digits for the range). [Table 3-4](#) also shows the maximum resolution and the input resistance for each range. (Resolution is a function of the specified integration time: refer to [Setting the integration time](#) later in this section for more information.) [Figure 3-1](#) shows the front terminal connections for all types of voltage measurements. In the power-on/PRESET NORM states, DC voltage measurements are selected. You can also specify DC voltage measurements using the DCV command. For example, to specify DC voltage measurements on the 1 V range, send:

OUTPUT 722;"DCV 1"

Table 3-4 DC voltage ranges

DCV range	Full scale reading	Maximum resolution	Input resistance
100 mV	120.00000 mV	10 nV	>10 GΩ ^[a]
1 V	1.20000000 V	10 nV	>10 GΩ ^[a]
10 V	12.0000000 V	100 nV	>10 GΩ ^[a]
100 V	120.000000 V	1 μV	10 MΩ
1000 V	1050.00000 V	10 μV	10 MΩ

[a] With FIXEDZ OFF. With FIXEDZ ON the input resistance is fixed at 10 MΩ. Refer to [Fixed input resistance](#) later in this chapter for more information.

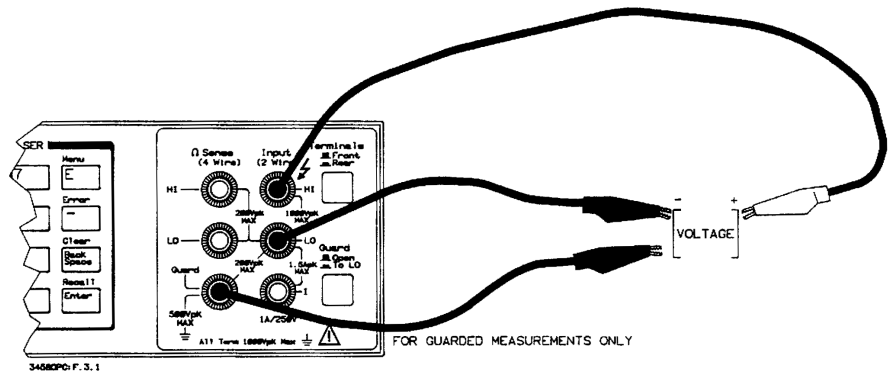


Figure 3-1 Voltage measurement connections

DC current

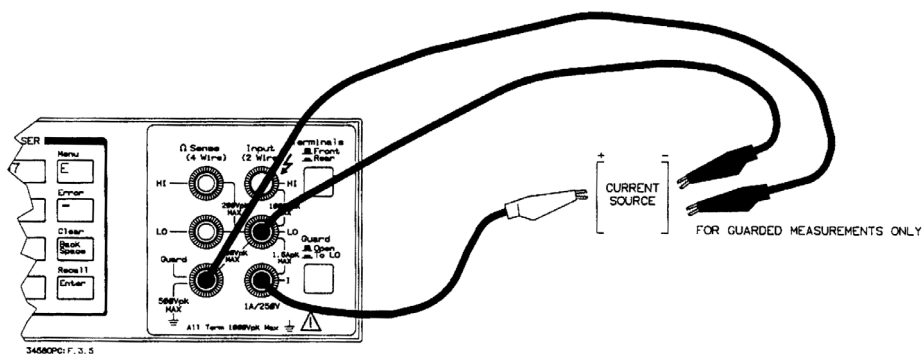
The multimeter measures current by placing an internal shunt resistor across the input terminals, measuring the voltage across the resistor, and calculating the current (current = voltage/resistance). The multimeter's front and rear current inputs are protected by 1 A, 250 V fuses. [Figure 3-2](#) shows the front terminal connections for all types of current measurements.

The multimeter measures DC current on any of eight ranges. [Table 3-5](#) shows each DC current range and its full-scale reading (the full scale reading also shows the maximum number of digits for each range). [Table 3-5](#) also shows the maximum resolution and the shunt resistor used for each range. (Resolution is a function of the specified integration time: refer to [Setting the integration time](#) later in the section for more information.) You specify DC current measurements using the DCI command. For example, to specify DC current measurements on the 10 μ A range, send:

```
OUTPUT 722;"DCI 10E-6"
```

Table 3-5 DC current ranges

DCI range	Full scale reading	Maximum resolution	Shunt resistor
100 nA	120.000 nA	1 pA	545.2 k Ω
1 μ A	1.200000 μ A	1 pA	45.2 k Ω
10 μ A	12.000000 μ A	1 pA	5.2 k Ω
100 μ A	120.00000 μ A	10 pA	730 Ω
1 mA	1.2000000 mA	100 pA	100 Ω
10 mA	12.000000 mA	1 nA	10 Ω
100 mA	120.00000 mA	10 nA	1 Ω
1 A	1.0500000 A	100 nA	0.1 Ω

**Figure 3-2** Current measurement connections

Resistance

The multimeter measures resistance by supplying a known current through the unknown resistance being measured. The current passing through the resistance generates a voltage across it. The multimeter measures this voltage and calculates the unknown resistance (resistance = voltage/current). [Table 3-6](#) shows each 2- and 4-wire ohms range and its full-scale reading (the full scale reading also shows the maximum number of digits for each range). [Table 3-6](#) also shows the maximum resolution and current sourced for each range. (Resolution is a function of the specified integration time: refer to [Setting the integration time](#) later in this section for more information.)

Table 3-6 Resistance ranges

OHM(F) range	Full scale reading	Maximum resolution	Current sourced
10 Ω	12.00000 Ω	10 $\mu\Omega$	10 mA
100 Ω	120.00000 Ω	10 $\mu\Omega$	1 mA
1 k Ω	1.2000000 k Ω	100 $\mu\Omega$	1 mA
10 k Ω	12.000000 k Ω	1 m Ω	100 μA
100 k Ω	120.00000 k Ω	10 m Ω	50 μA
1 M Ω	1.2000000 M Ω	100 m Ω	5 μA
10 M Ω	12.000000 M Ω	1 Ω	500 nA
100 M Ω	120.00000 M Ω	10 Ω	500 nA
1 G Ω	1.2000000 G Ω	100 Ω	500 nA

2-wire ohms

Two-wire ohms is most commonly used when the resistance of the test leads is much less than the value being measured. If the lead resistance is large compared to the resistance to be measured, readings will be inaccurate. For example, suppose you are measuring a 1 Ω resistor located 10 feet away. If you use 24-gauge copper wire to make the connections, the 20 feet of leads contribute about 0.5 ohms to the measurement. This makes the total measurement 1.5 ohms--an error of 50%. Some other factors that may cause high lead resistance are loose or dirty connections, kinked or damaged wires, or a very hot

environment. You can enhance the accuracy of 2-wire ohms measurements with the NULL math operation (refer to **NULL** in **Chapter 4** for more information).

Figure 3-3 shows the front connections for 2-wire ohms measurements. You specify 2-wire ohms measurements using the OHM command. For example, to specify 2-wire ohms measurements on the 1 k Ω range, send:

```
OUTPUT 722; "OHM 1E3"
```

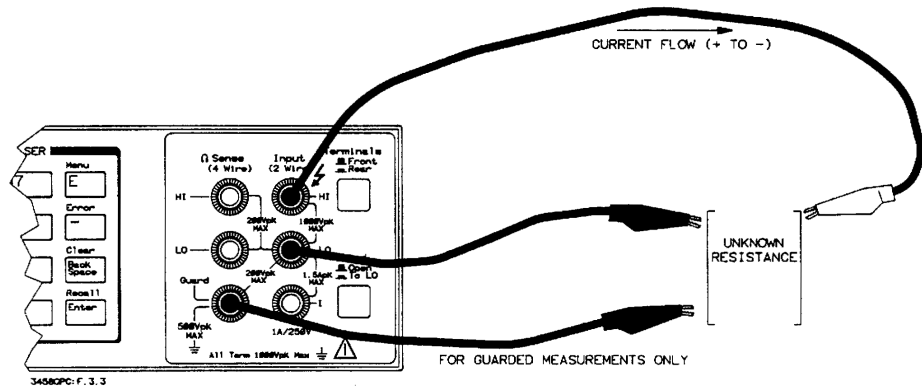


Figure 3-3 2-Wire ohms measurement connections

4-wire ohms

The 4-wire ohms mode eliminates the measurement error caused by test lead resistance. In 2-wire ohms, the voltage measurement is made across the combined resistance of the test leads and the unknown resistance. In 4-wire ohms, the voltage is measured across the unknown resistance only, not the combined resistance. This is important when the test lead resistance is high in comparison to the resistance being measured. **Figure 3-4** shows the front connections for 4-wire ohms measurements. You specify 4-wire ohms measurements using the OHMF command. For example, to specify 4-wire ohms measurements on the 10 M Ω range, send:

```
OUTPUT 722; "OHMF 10E6"
```

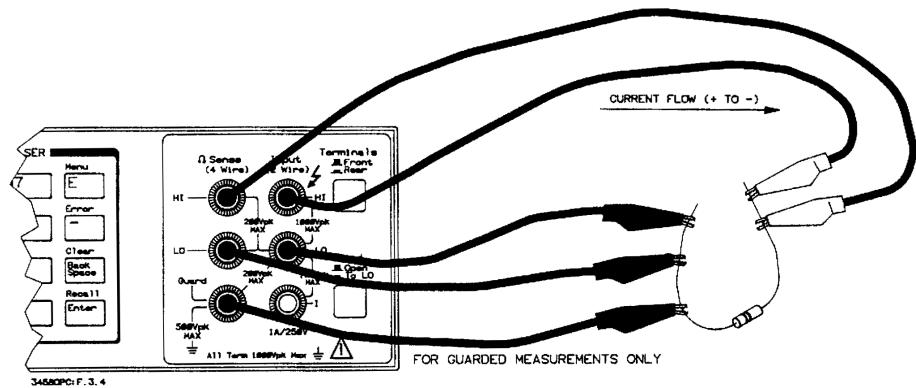


Figure 3-4 4-Wire ohms measurement connections

Configuring the A/D converter

The A/D converter's configuration determines the measurement speed, resolution, accuracy, and normal mode rejection^[1] for DC or ohms measurements. The factors that affect the A/D converter's configuration are the reference frequency, the specified integration time, and the specified resolution.

The reference frequency

When power is applied, the multimeter measures the power line frequency, rounds the value to 50 Hz or 60 Hz, and sets the A/D converter's *reference frequency* to the rounded value. (For a 400 Hz power line frequency, the multimeter uses 50 Hz as the *reference frequency*, which is a subharmonic of 400 Hz.) For DC or ohms measurements, the multimeter achieves normal mode rejection (NMR) for noise at the reference frequency when the integration time is ≥ 1 power line cycle. See [Setting the integration time](#) (following) for more information.

[1] Normal mode rejection (NMR) is the multimeter's ability to reject noise at the power line frequency from DC or ohms measurements.

Changing the reference frequency

For most operating conditions, the power-on reference frequency allows for excellent NMR. However, for maximum NMR you should set the reference frequency to the exact power line frequency. (If your power line frequency is subject to drift, you may have to periodically correct the reference frequency.) The following command measures the power line frequency and sets the reference frequency to the exact measured value (for a 400 Hz line frequency, the multimeter divides the measured value by 8 and uses that as the reference frequency).

OUTPUT 722; "LFREQ LINE"

You can also use the LFREQ command to directly specify the reference frequency. This is particularly useful when the multimeter has a different power line frequency than the device being measured. Suppose, for example, the multimeter has a power line frequency of 60 Hz and the device being measured has a power line frequency of 50 Hz. For this application you can achieve NMR by setting the reference frequency to 50 Hz as follows:

OUTPUT 722; "LFREQ 50"

Remember that whenever power is cycled or the front panel **Reset** key is pressed, the reference frequency returns to the rounded value of 50 or 60 Hz.

Setting the integration time

Integration time is the period of time that the A/D converter measures the input signal. For DC or ohms measurements, the integration time determines the measurement speed, accuracy, maximum digits of resolution, and the amount of NMR for noise at the A/D converter's reference frequency. You can specify integration time in terms of power line cycles (PLCs) using the NPLC command or directly (in seconds) using the APER command. Since the NPLC and APER commands both set the integration time, executing either will cancel the integration time previously established by the other.

Specifying power line cycles

The multimeter achieves NMR for noise at the A/D converter's reference frequency when the integration time is ≥ 1 power line cycles. You can specify integration time in terms of power line cycles (PLCs) using the NPLC command. The multimeter multiplies the specified number of PLCs by the period of the A/D converter's reference frequency (LFREQ command) to determine the integration time. For example, the period of a 50 Hz power line is $1/50 = 20$ msec. If you

specify 10 PLCs, the integration time is 200 msec. In the power-on state, integration time is set to 10 PLCs. In the PRESET NORM state, integration time is set to 1 PLC. To set the integration time for the fastest measurements (with the lowest accuracy, lowest resolution, and no NMR), send:

OUTPUT 722; "NPLC 0"

To specify the most accuracy, highest resolution, and 80 dB of NMR for DC or ohms measurements (with the slowest measurement speed), send:

OUTPUT 722; "NPLC 1000"

You can specify power line cycles in the following ranges:

- 0 - 1 PLC (in .000006 PLC steps for 60 Hz ref. frequency or .000005 PLC steps for 50 Hz ref. frequency)
- 1- 10 PLC in 1 PLC steps
- 10 - 1000 PLCs in 10 PLC steps

NOTE

For integration times greater than 10 PLCs, the multimeter averages a number of readings made using 10 PLCs of integration time. For example, if you specify 60 PLCs, the multimeter averages six 10 PLC readings.

The wide range of PLC settings provides flexibility in the selection of measurement speed, accuracy, resolution, and NMR. Typically, you should select the integration time that provides adequate speed while maintaining an acceptable amount of resolution and NMR. The specifications tables in [Appendix A](#) show the relationship of integration time to digits of resolution and NMR for DC and ohms measurements.

Specifying integration time directly

For DC or ohms measurements, you can specify the integration time directly (in seconds) using the APER (aperture) command. For example, to specify 22 ms of integration time, send:

OUTPUT 722; "APER.022"

NOTE

When using the APER command, the multimeter does not average readings for long integration times as it does with the NPLC command. For example, if you specify 60 = PLCs (1 second of integration time at a 60 Hz = line frequency) using the NPLC command, the multimeter averages six 10 PLC readings. If you specify 1 second of integration time using the APER command, the multimeter integrates a single reading for 1 second.

With the APER command, you can specify integration time from 500 ns to 1 s in increments of 100 ns. The APER command is most commonly used when sampling a specific part of a signal (such as a pulse) or for digitizing. You can also use the APER command to reject a noise signal of a specific frequency from the input signal. To do this, set the integration time equal to an integral multiple of the period of the signal to be rejected. For example, to reject noise at 100 Hz (period = 10 ms), specify an integration time of 10 ms, 20 ms, 30 ms, etc.

Specifying resolution

You specify the measurement resolution as the last parameter of a function command (FUNC, ACV, DCV, etc.) or the RANGE command.^[1] This parameter is called *%_resolution* since you specify it as a percentage of the command's *max._input* parameter (see [Specifying the range](#) earlier in this chapter). The multimeter multiplies the specified *%_resolution* parameter times the *max._input* parameter to determine the measurement resolution. To compute the *%_resolution* parameter, use the equation:

$$\%\_resolution = (\text{actual resolution}/\text{maximum input}) \times 100$$

For example, suppose the maximum expected input is 10 VDC and you need 1 mVDC of resolution. The equation evaluates to:

$$\%\_resolution = (0.001/10) \times 100 = 0.01$$

If you default the *%_resolution* parameter, the integration time will be that specified by the last APER or NPLC command executed.

For DC or ohms measurements (and analog AC measurements), resolution is determined by the A/D converter's integration time. When you specify a resolution, you are actually indirectly specifying an integration time. Since the

[1] You can also specify resolution using the RES command. Refer to the RES command in [Chapter 6](#) for examples showing its usage.

APER or NPLC command can also specify an integration time, an interaction occurs when you specify resolution as follows:

- If you send the APER or NPLC command *before* specifying resolution, the multimeter satisfies the command that specifies greater resolution (more integration time).
- If you send the APER or NPLC command *after* specifying resolution, the multimeter uses the integration time specified by the APER or NPLC command, and any previously specified resolution is ignored.

When to specify resolution

For DC or ohms measurements, you should specify resolution when the resolution provided by the NPLC or APER command is not sufficient. For example, in the following program, line 10 specifies 1 PLC of integration time which provides 60 dB of NMR and 7½ digits of resolution. This produces an actual resolution of 1 µV on the 10 V range. For this application, 100 nV of resolution is required with a *max_input* of 10 V. The preceding equation produces a *%_resolution* parameter of 0.000001 (1E-6). This is specified in line 20.

```
10 OUTPUT 722;"NPLC 1"
20 OUTPUT 722;"DCV 10, 1E-6"
30 END
```

Autozero

The autozero function ensures that any offset errors internal to the multimeter are nulled from subsequent DC or ohms measurements. The autozero function is controlled using the AZERO command. With AZERO ON, the multimeter internally disconnects the input signal and makes a zero reading following every measurement. It then algebraically subtracts the zero reading from the preceding measurement. With AZERO OFF or ONCE, the multimeter takes one zero reading and algebraically subtracts this from subsequent readings. After you execute AZERO OFF or AZERO ONCE, the multimeter takes the autozero measurement when the first trigger arm event occurs for all events except TARM EXT which causes an autozero measurement when the TARM EXT command is executed. (The trigger arm event is discussed in [Chapter 4](#).) The autozero measurement is updated whenever the measurement function, range, or integration time is changed (this update is made when the trigger arm event occurs or TARM EXT is executed). In the power-on/PRESET NORM state, AZERO is set to ON. You can change it by sending:

```
OUTPUT 722;"AZERO OFF"
```

NOTE

You should leave autozero on (AZERO ON command) for 4-wire ohms measurements. If you must disable autozero (AZERO OFF or ONCE), be sure to make all measurement connections before disabling autozero and ensure that the lead resistance will not change. If you disable autozero before making the 4-wire connections, or if you have a varying lead resistance with autozero disabled (such as when scanning), you may get inaccurate 4-wire ohms measurements.

Offset compensation

Because a resistance measurement involves measuring the voltage induced across the resistance, any external voltage present (offset voltage) will affect the measurement accuracy. With offset compensation enabled, the multimeter corrects resistance measurements by canceling the effects of the offset voltage. To do this, the multimeter first measures the input voltage with its current source on. The current source is then disabled and the input voltage measured again. The true induced voltage is the difference between the two measured voltages. You can use offset compensation for both 2-wire and 4-wire ohms measurements. The multimeter can only perform offset compensation on the 10 Ω through 100 k Ω ranges; offset compensation does not function on the other ranges. In the power-on/PRESET NORM state, offset compensation is disabled. To enable offset compensation, send:

```
OUTPUT 722:"OCOMP ON"
```

Refer to the [Appendix A](#) for specifications concerning the maximum series offset voltage for offset compensated ohms measurements.

Fixed input resistance

When making DC voltage measurements, you can fix the multimeter's input resistance using the FIXEDZ command. This is useful to prevent a change in input resistance (caused by changing ranges) from affecting the measurements.

[Table 3-4](#) shows the input resistances with FIXEDZ OFF. With FIXEDZ ON, the input resistance is a constant 10 M Ω for all DC voltage ranges. In the power-on/PRESET NORM state, fixed resistance is disabled (OFF). To enable fixed resistance, send:

```
OUTPUT 722; "FIXEDZ ON"
```

To disable fixed resistance, send:

```
OUTPUT 722; "FIXEDZ OFF"
```

Configuring for AC Measurements

This section describes how to configure the multimeter for making AC or AC+DC voltage, AC or AC+DC current, frequency, or period measurements.

AC or AC+DC voltage

The multimeter can make true RMS AC voltage or AC+DC voltage measurements using one of three methods: analog RMS conversion, random sampling conversion, or synchronous sampling conversion. Each measurement method has six ranges: 10 mV, 100 mV, 1 V, 10 V, 100 V and 1000 V, and a maximum resolution of 6½ digits on any range.

Table 3-7 shows the measurement characteristics and signal requirements for each measurement method. Figure 3-1 shows the front terminal connections for all types of voltage measurements.

For AC voltage measurements, the multimeter measures only the AC component of the input signal. For AC+DC voltage measurements, the multimeter measures the DC component and the AC component within the frequency ranges shown in Table 3-7. Notice that when measuring AC+DC voltage using the analog method, for example, any AC components below 10 Hz are not included in the measurement.

NOTE

When taking measurements on the 10 mV and 100 mV ranges using any AC measurement method, it is possible for radiated noise (such as transients caused by large motors turning on and off) to cause inaccurate readings. For accurate readings on these ranges, ensure that your nearby environment is electrically “quiet” and use shielded test leads.

Table 3-7 AC and AC+DC voltage measurement methods

ACV/ACDCV measurement method	Frequency range	Best accuracy	Repetitive signal required	Readings per second	
				Min.	Max.
Synchronous	1 Hz - 10 MHz	0.01%	Yes	0.025	10
Analog	10 Hz - 2 MHz	0.03%	No	0.8	50
Random	20 Hz - 10 MHz	0.10%	No	0.025	45

Synchronous sampling conversion

The synchronous sampling conversion calculates the true RMS value from samples, but requires that the input signal be repetitive (periodic). Synchronous sampling has excellent linearity and is the most accurate of the three methods. Synchronous sampling is useful for measuring periodic waveforms in the frequency range of 1 Hz to 10 MHz.

Synchronous sampling remarks

- For synchronous sampling, the multimeter uses the LEVEL sync source event (default mode) to synchronize sampling to the input signal. If the input signal is removed during a reading and does not return within a certain amount of time, (the time limits are determined primarily by the AC bandwidth setting which is discussed later in this section) the measurement method changes to random sampling so that a measurement can be made. You can prevent the measurement method from changing using the SSRC command. You can also pace synchronous sampling to a signal on the Ext Trig connector using the SSRC command. Refer to the SSRC command in [Chapter 6](#) for more information and example programs.
- When using the LEVEL sync source, it is possible for noise on the input signal to produce false level triggers and to cause inaccurate readings. For accurate readings, ensure that your nearby environment is electrically “quiet” and use shielded test leads. Enabling level filtering (LFILTER ON command) reduces the sensitivity to this noise. Refer to the LFILTER command in [Chapter 6](#) for more information.
- The input signal is always DC-coupled for synchronous sampling regardless of the specified ACV or ACDCV measurement function. When ACV is specified, the DC components are mathematically subtracted from the reading. This is

important to consider since the combined AC and DC voltage levels may cause an overload condition even though the AC voltage alone normally would not.

Analog RMS conversion

The analog RMS conversion directly integrates the input signal and is the method selected when power is applied. This method works well for measuring signals in the frequency range of 10 Hz to 2 MHz and can provide the fastest reading rate of the three methods.

Random sampling conversion

The random sampling conversion takes numerous samples of the input signal for each reading generated. Samples are spaced randomly by an internal time base generator and the signal's true RMS value is calculated statistically. Random sampling does not require a repetitive input signal (as does synchronous sampling) making it suitable for applications such as wideband noise measurements. This method has excellent linearity, good accuracy, and is particularly suited to low-level ($<1/10$ of full scale) measurements. The measurement bandwidth for random sampling is 20 Hz to 10 MHz.

Specifying the AC voltage method

When power is applied, the multimeter selects the analog RMS conversion. In the power-on state, you can make measurements using the analog RMS conversion simply by selecting AC or AC+DC voltage measurements as follows:

OUTPUT 722; "ACV"

!SELECTS AC-COUPLED AC VOLTAGE MEASUREMENTS

or

OUTPUT 722; "ACDCV"

!SELECTS DC-COUPLED AC VOLTAGE MEASUREMENTS

The SETACV command allows you to specify the AC voltage measurement method. For example, to specify the random sampling conversion, send:

OUTPUT 722; "SETACV RNDM"

To select the synchronous sampling conversion, send:

OUTPUT 722; "SETACV SYNC"

To return to the analog RMS conversion, send:

OUTPUT 722; "SETACV ANA"

The specified AC voltage measurement method remains in effect until power is cycled, the multimeter is reset, or another method is specified. Whenever you select AC or AC+DC voltage measurements, the last specified (or power-on) measurement method will be used.

AC or AC+DC current

The multimeter measures current by placing an internal shunt resistor across the input terminals, measuring the voltage across the resistor, and calculating the current (current = voltage/resistance). Unlike AC or AC+DC voltage measurements, AC or AC+DC current measurements can be made using the analog method (direct integration) only. The multimeter's front and rear current inputs are protected by 1 A, 250 V fuses. [Figure 3-2](#) shows the front terminal connections for all types of current measurements.

The multimeter measures AC or AC+DC current on any of five ranges. For AC current measurements, the multimeter measures only the AC component of the input signal. For AC+DC current measurements, the multimeter measures the DC component and the AC component with frequencies >10 Hz. Notice that when measuring AC+DC current, any AC components below 10 Hz are not included in the measurement. The maximum resolution for AC or AC+DC current is 6½, digits. [Table 3-8](#) shows each current range and its full scale reading, maximum resolution, and the shunt resistor used. (Resolution is a function of the specified integration time; refer to [Setting the integration time](#), later in this section, for more information.) You specify AC current measurements using the ACI command or AC+DC current measurements using the ACDCl command. For example to specify AC current measurements on the 100 µA range, send:

```
OUTPUT 722;"ACI 100E-6"
```

To specify AC+DC current measurements on the 10 mA range, send:

```
OUTPUT 722;"ACDCl 10E-3"
```

Table 3-8 AC and AC+DC current ranges and resolution

ACI range	Full scale reading	Maximum resolution	Shunt resistor
100 μ A	120.0000 μ A	100 pA	730 Ω
1 mA	1.200000 mA	1 nA	100 Ω
10 mA	12.000000 mA	10 nA	10 Ω
100 mA	120.0000 mA	100 nA	1 Ω
1 A	1.050000 A	1 μ A	0.1 Ω

Frequency or period

The multimeter's frequency and period counter accepts AC voltage or AC current inputs. The maximum resolution is 7 digits^[1] for both frequency and period measurements. (Refer to [Specifying resolution](#) later in this section, for more information).

You specify frequency measurements using the FREQ command or period measurements using the PER command. For frequency or period measurements you must also specify whether the input signal is from a voltage source or a current source and whether the measurements will be AC or DC coupled. This is done using the FSOURCE command (the power-on/default value is ACV).

[Table 3-9](#) shows the FSOURCE parameters, the type of input specified by each, and the measurement capabilities of each. The terminal connections for frequency or period measurements from a voltage source are shown in [Figure 3-1](#). The terminal connections for frequency or period measurements from a current source are shown in [Figure 3-1](#).

NOTE

The LEVEL command affects the zero crossing threshold and the input signal coupling for frequency and period measurements. Refer to the LEVEL command in [Chapter 6](#) for more information.

[1] The leftmost digit, which is a ½ digit for most measurement functions is a full digit (0-9) for frequency and period measurements.

Table 3-9 FSOURCE parameters

FSOURCE parameter	Definition	Measurement capabilities	
		Frequency	Period
ACV	AC-coupled AC voltage input	1 Hz – 10 MHz	100 ns – 1 s
ACDCV	DC-coupled AC voltage input	1 Hz – 10 MHz	100 ns – 1 s
ACI	AC-coupled AC current input	1 Hz – 100 kHz	10 μ s – 1 s
ACDCI	DC-coupled AC current input	1 Hz – 100 kHz	10 μ s – 1 s

The following program configures the multimeter for frequency measurements on the 10 V range from a voltage Source. The input signal is AC-coupled.

```
10 OUTPUT 722;"FREQ 10"
20 OUTPUT 722;"FSOURCE ACV"
30 END
```

The following program configures the multimeter for period measurements on the 10 mA range from a current source. The input signal is DC-coupled.

```
10 OUTPUT 722;"PER 10E-3"
20 OUTPUT 722;"FSOURCE ACDCI"
30 END
```

NOTE

You can reduce high-frequency noise above 75 kHz for frequency or period measurements by enabling the level filter. Refer to the LFILTER command in [Chapter 6](#) for details.

Specifying bandwidth

The ACBAND command specifies the frequency content of the input signal for all AC and AC+DC measurements. Specifying the frequency content allows the multimeter to make accurate measurements and to configure itself for the fastest possible measurements. The ACBAND command's first parameter specifies the lowest expected frequency component (the power-on/PRESET NORM value is 20 Hz). The second parameter specifies the highest expected frequency

component (the power-on/PRESET NORM value is 2 MHz). For example, suppose the input signal has a frequency range of 750 Hz to 2 kHz; you should send:

```
OUTPUT 722;"ACBAND 750,2000"
```

Refer to the “[Appendix A: Specifications](#)” on page 409 for accuracy specifications (and reading rate specifications for analog AC measurements) based on the frequency components of the input signal.

NOTE

For synchronous AC or AC + DC voltage measurements, the bandwidth parameters are used by the multimeter to calculate time-out values and sampling parameters. For frequency or period measurements with autorange enabled, the bandwidth parameters are used to determine the amount of time needed for autoranging. For these measurements, it is very important that the specified bandwidth (particularly the specified low frequency) corresponds to the frequency content of the input signal.

Setting the integration time

Integration time is the period of time that the A/D converter measures the input signal. For analog AC measurements, the integration time determines the maximum digits of resolution and, along with the specified bandwidth affects the measurement speed. (Integration time also has a minor affect on analog AC measurement accuracy). Analog AC measurements are defined as AC or AC+DC voltage measurements made using the analog conversion method (SETACV ANA command) only, and AC or AC+DC current measurements. With longer integration times, the measurement resolution and accuracy increases, but measurement speed decreases.

NOTE

The integration time has no effect on frequency or period measurements. For sampled AC voltage measurements (SET ACV SYNC or SET ACV RNDM) the A/D converter's integration time is selected automatically and the multimeter achieves the specified resolution ([Specifying resolution](#) is discussed in the next section) by varying the number of samples taken.

For analog AC measurements, you can specify integration time in terms of power line cycles (PLCs) using the NPLC command. (You can also use the APER command to specify integration time although it is primarily intended for DC

measurements; refer to the APER command in [Chapter 6](#) for more information.) The multimeter multiplies the specified number of PLCs by the period of the A/D converter's reference frequency (LFREQ command) to determine the integration time. For example, the period of a 50 Hz power line is $1/50 = 20$ msec. If you specify 10 PLCs, the integration time is 200 msec. In the power-on state, integration time is set to 10 PLCs. In the PRESET NORM state, integration time is set to 1 PLC. To set the integration time for the fastest measurements (with the lowest accuracy and $4\frac{1}{2}$, digits of resolution), send:

OUTPUT 722; "NPLC 0"

To specify the most accuracy and Highest resolution ($6\frac{1}{2}$ digits), with the slowest measurement speed, send:

OUTPUT 722; "NPLC 1000"

You can specify power line cycles in the following ranges:

- 0 - 1 PLC (in .000006 PLC steps for 60 Hz ref. frequency or .000005 PLC steps for 50 Hz ref. frequency)
- 1- 10 PLC in 1 PLC steps
- 10 - 1000 PLCs in 10 PLC steps

NOTE

For integration times greater than 10 PLCs, the multimeter averages a number of readings made using 10 PLCs of integration time. For example, if you specify 60 PLCs of integration time, the multimeter averages six 10 PLC readings.

Typically, you should select the integration time that provides adequate speed while maintaining an acceptable amount of accuracy and resolution. [Table 3-10](#) shows the relationships between integration time and digits of resolution for analog AC measurements.

Table 3-10 Analog AC A/D converter relationships

Digits of resolution	Power line cycles (NPLC command)	
	LFREQ = 60 Hz	LFREQ = 50 Hz
4.5	0 – .000030	0 – .000025
5.5	.000036 – .000360	.000030 – .000300
6.5	.000366 – 1000	.000305 – 1000

Specifying resolution

You can specify the measurement resolution as the last parameter (*%_resolution* parameter) of a function command (FUNC,ACV, ACI, etc.) or the RANGE command.^[1]

For all analog AC voltage and current measurements *%_resolution* is specified as a percentage of the command's *max._input* parameter. The multimeter multiplies the specified *%_resolution* parameter times the *max._input* parameter to determine the measurement resolution. To determine the value of the *%_resolution* parameter, use the equation:

$$\%\_resolution = (\text{actual resolution}/\text{maximum input}) \times 100$$

For example, suppose your maximum expected input is 10 VAC and you need 1 mVAC of resolution. The equation evaluates to:

$$\%\_resolution = (0.001/10) \times 100 = 0.01$$

For analog AC measurements, resolution is determined by the A/D converter's integration time. When you specify a resolution, you are actually indirectly specifying an integration time. Since the NPLC command can also specify an integration time, an interaction occurs when you specify resolution as follows:

- If you send the NPLC command *before* specifying resolution, the multimeter satisfies the command that specifies greater resolution (more integration time).
- If you send the NPLC command *after* specifying resolution, the multimeter uses the integration time specified by the NPLC command, and the previously specified resolution is ignored.

[1] You can also specify resolution using the RES command. Refer to the RES command in [chapter 6](#) for examples showing its usage.

For analog AC measurements, if you default, the `%_resolution` parameter, the integration time will be that specified by the last NPLC command executed.

For sampled ACV or ACDCV, random sampling (SETACV RNDM) has a fixed resolution of 4.5 digits that cannot be changed. For synchronous sampling (SETACV SYNC) a `%_resolution` parameter of 0.001 = 7.5 digits; 0.01 = 6.5 digits; 0.1 = 5.5 digits; and 1 = 4.5 digits.

For frequency and period measurements, `%_resolution` specifies the gate time and the digits of resolution as shown in [Table 3-11](#). For example, the following program specifies frequency measurements from a voltage input using the 10 V range. The `%_resolution` parameter in line 20 (.00001) specifies a gate time of 1 second and 7 digits of resolution.

```
10 OUTPUT 722; "FSOURCE ACV"
20 OUTPUT 722; "FREQ 10, .00001"
30 END
```

If you default the `%_resolution` parameter for FREQ or PER measurements, the multimeter sets `%_resolution` to .00001 which selects a gate time of 1 second and 7 digits of resolution.

Table 3-11 Frequency/Period gate time and resolution

<code>%_resolution</code> parameter	Selects gate time	Digits of resolution
.00001	1 s	7
.0001	100 ms	7
.001	10 ms	6
.01	1 ms	5
.1	100 μ s	4

When to specify resolution

For analog ACV or ACDCV (SETACV ANA), ACI, and ACDCI measurements, you should specify resolution when you need more resolution than that provided by the NPLC command. For example, in the following program, line 10 specifies 0.0001 PLC of integration time, which selects 5½, digits of resolution resulting in an actual resolution of 100 μ V on the 10 V range. However, for this application, 10 μ V of resolution is required with a `max_input` of 10 V. The preceding equation

produces a *%_resolution* parameter of 0.0001 (1E-4) which is specified in line 30 (for this resolution, a reading takes about 40 seconds).

```
10 OUTPUT 722;"NPLC .0001"  
20 OUTPUT 722;"SETACV ANA"  
30 OUTPUT 722;"ACV 10,1E-4"  
40 END
```

For synchronous sampled ACV or ACDCV (SETACV SYNC), FREQ, and PER measurements specifying resolution is the only way to change the actual resolution. For these measurements, the integration time is fixed and no interaction occurs between the NPLC command and the *%_resolution* parameter. The multimeter achieves the specified resolution for sampled AC voltage by varying the number of samples taken. (If you default the *%_resolution* parameter, the multimeter sets the *%_resolution* to 0.01 percent for the synchronous conversion method or 0.4 percent for the random conversion method.) The following program selects AC voltage measurements using the synchronous sampling conversion. The maximum expected input voltage is 10 volts and a *%_resolution* parameter of .1 selects 5.5 digits resulting in an actual resolution of 0.1 mV.

```
10 OUTPUT 722; "SETACV SYNC"  
20 OUTPUT 722;"ACV 10, .1"  
30 END
```


Configuring for Ratio Measurements

For ratio measurements, the multimeter measures a DC reference voltage applied to the Ω Sense terminals and a signal voltage applied to the Input terminals. The multimeter then computes the ratio as:

$$\text{Ratio} = \frac{\text{Signal Voltage}}{\text{DC Reference Voltage}}$$

The signal voltage measurement function can be DC voltage, AC voltage, or AC+DC voltage. (For AC or AC+DC voltage, any of the three measurement methods ANA, RNDM, or SYNC may be used.) The reference voltage measurement function is always DC voltage and has a maximum measurable input of ± 12 VDC. **Figure 3-5** shows the front connections for ratio measurements.

NOTE

The Ω Sense LO and the Input LO terminals must have a common reference and cannot have a voltage difference greater than 0.25 V.

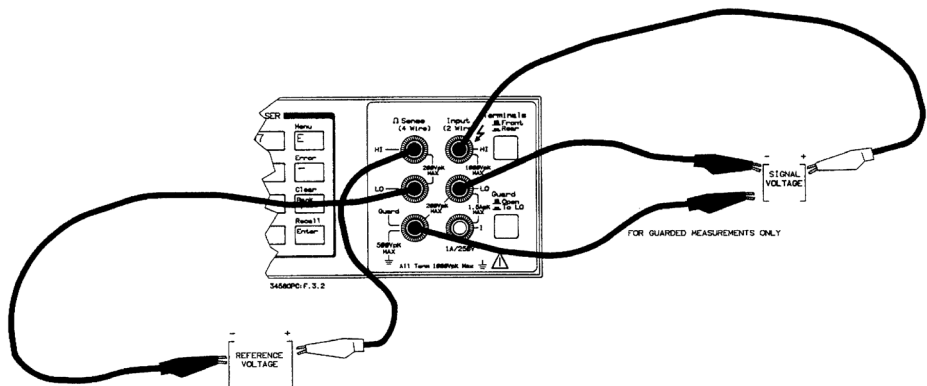


Figure 3-5 Ratio measurement connections

Specifying ratio measurements

To specify ratio measurements, you first select the measurement function for the signal measurement (and the measurement method for AC or AC+DC voltage) and then enable ratio measurements using the **RATIO** command. For example, the following program specifies AC voltage ratio measurements (on the 10 V range) using the synchronous sampling conversion.

```
10 OUTPUT 722;"ACV 10"  
20 OUTPUT 722; "SETACV SYNC"  
30 OUTPUT 722;"RATIO ON"  
40 END
```

Later, to disable ratio measurements, send:

```
OUTPUT 722;"RATIO OFF"
```

For ratio measurements, the specified measurement range applies to the signal voltage measurement only (Input terminals). The reference voltage measurement (Ω Sense terminals) is always set to autorange. Ranging is discussed in detail earlier in this chapter under [General Configuration](#).

Using Subprogram Memory

The multimeter can store command strings as subprograms. This allows you to execute frequently used command strings while keeping bus/controller interaction to a minimum. Since stored subprograms are compiled, the multimeter executes a subprogram much faster than it could execute the equivalent commands sent over the GPIB. The multimeter has 14k-bytes of memory that are shared by subprograms and states (discussed later). When subprogram/state memory becomes full, the multimeter generates the *Memory Error* (bit 7 in the error register).

NOTE

The status register contains a subprogram complete bit that can be used to determine when a subprogram has finished executing. Refer to [Using the Status Register](#) later in this chapter, for more information.

Storing a subprogram

You store a subprogram using the SUB and SUBEND commands. The SUB command indicates the start of the subprogram and its identifying name. A subprogram name may contain up to 10 characters. The name can be all alpha characters or a combination of alpha and numeric characters (the characters ? and _ can also be included in the name). When using an alphanumeric name, the first character must be alpha. Alpha or alphanumeric subprogram names must not be the same as multimeter commands or parameters or the name of a stored state.

Following the SUB command, enter the subprogram commands in the order you want them executed. Use the SUBEND command to indicate the end of the subprogram. All subprograms are stored in continuous memory (remain intact when power is removed) unless the subprogram is compressed (see [Compressing subprograms](#) later in this chapter). For example, the following program stores the commands in lines 20 through 60 as a subprogram entitled DCCUR1.

```
10 OUTPUT 722;"SUB DCCUR1"
20 OUTPUT 722;"MEM FIFO"
30 OUTPUT 722;"TRIG HOLD"
40 OUTPUT 722;"DCI 1,.01"
50 OUTPUT 722;"NRDGS 5, AUTO"
```

```

60 OUTPUT 722;"TRIG SGL"
70 OUTPUT 722; "SUBEND"
80 END

```

If you create a new subprogram using the same name as an existing subprogram, the new subprogram overwrites the old subprogram.

Executing a subprogram

To execute a stored subprogram, issue the CALL command along with the subprogram's name. For example, to execute the preceding subprogram, send:

```
OUTPUT 722;"CALL DCCUR1"
```

NOTE

When the input buffer (discussed later in this chapter) is off, the multimeter does not release the GPIB until the completion of the subprogram or a PAUSE command (discussed below) is encountered. Refer to [Using the Input Buffer](#), later in this chapter for information on how to release the bus immediately after calling a subprogram. To abort subprogram execution, send the GPIB Device Clear command.

From the front panel, you can view all stored subprogram names by accessing the CALL command and pressing the up or down arrow key. Once you have found the correct subprogram, press the **Enter** key to execute the subprogram.

Suspending subprogram execution

You can temporarily suspend subprogram execution by including the PAUSE command in the stored subprogram. The multimeter executes subprograms on a command-by-command basis. When it encounters the PAUSE command, subprogram execution is suspended and, if the subprogram was called from remote, the GPIB bus is released. For example, the following program has a PAUSE command in line 60.

```

10 OUTPUT 722; "SUB 2"
20 OUTPUT 722;"MEM FIFO"
30 OUTPUT 722;"TRIG HOLD"
40 OUTPUT 722;"DCV 10"

```

```

50 OUTPUT 722;"NRDGS 5,AUTO"
60 OUTPUT 722;"PAUSE"
70 OUTPUT 722;"TRIG SGL"
80 OUTPUT 722;"SUBEND"
90 END

```

When you call the above subprogram, the commands will be executed up to the PAUSE command and then program execution ceases. To resume subprogram execution, send:

```
OUTPUT 722;"CONT"
```

Subprogram execution can also be resumed by sending the GPIB Group Execute Trigger (this does not in itself trigger a reading: it merely resumes subprogram operation).

Nested subprograms

You can use a subprogram to call another subprogram (nested subprograms). For example, when the following subprogram is called (CALL 1 command), it takes 10 DC voltage readings and then calls the previously stored subprogram *DCCUR1*.

```

10 OUTPUT 722; "SUB 1"
20 OUTPUT 722;"TRIG HOLD"
30 OUTPUT 722;"NRDGS 10,AUTO"
40 OUTPUT 722;"DCV 10"
50 OUTPUT 722;"TRIG SGL"
60 OUTPUT 722; "CALL DCCUR1"
70 OUTPUT 722; "SUBEND"
80 END

```

A subprogram containing a PAUSE command cannot be called from another subprogram. The multimeter allows you to nest up to 10 subprograms; that is having subprogram 1 call subprogram 2 which calls 3, which calls 4 ... which calls subprogram 10.

Autostart subprogram

When you entitle a subprogram 0, that subprogram will be executed whenever the multimeter completes its power-on sequence or it is reset using the front panel **Reset** key. This is particularly useful to automatically return the multimeter to its previous state following a power failure. Whenever a power failure is detected, the multimeter stores its present state as state 0 (states are discussed later in this chapter). The following program stores an autostart program that returns the multimeter to its power-down state and also sets the A/D converter's reference frequency to the exact power line frequency (see [Changing the reference frequency](#) earlier in this chapter for details).

```
10 OUTPUT 722; "SUB 0"
20 OUTPUT 722; "RSTATE 0"
30 OUTPUT 722; "LFREQ LINE"
40 OUTPUT 722; "SUBEND"
50 END
```

You can also call the autostart subprogram (CALL 0 command) if you need to execute the subprogram without having to cycle the multimeter's power.

Compressing subprograms

When you store a subprogram, the multimeter stores the ASCII text in continuous memory and a compiled version of the subprogram in volatile memory. When you call a subprogram, the multimeter executes the compiled version (this is why a subprogram executes faster than the equivalent commands sent over the bus). When power is removed, only the ASCII text is saved. When power is reapplied, the multimeter uses the ASCII text to generate a compiled subprogram. You can compress subprograms using the COMPRESS command. Compressing a subprogram removes the ASCII text from continuous memory leaving only the compiled version in volatile memory. This makes more continuous memory space available but removes the subprogram from continuous memory (all record of the subprogram will be destroyed when power is removed or the front panel **Reset** key is pressed). The following program statement compresses the previously stored subprogram named *DCCUR1*.

```
OUTPUT 722; "COMPRESS DCCUR1"
```

Deleting subprograms

The DELSUB command deletes a particular subprogram. For example, to delete the subprogram named *DCCUR1* send:

```
OUTPUT 722; "DELSUB DCCUR1"
```

You can also delete all stored subprograms and all stored states using the SCRATCH command.

Using State Memory

You can store the multimeter's present configuration (measurement function, range, resolution, integration time, etc.) as a particular state in state memory. Subprograms, readings, and the contents of some math registers (see the SSTATE command in [Chapter 6](#) for details) are not included as part of a stored state. In the event of a power loss, the multimeter stores its present configuration in state 0; if you store a state in location 0, it will be overwritten with the present configuration when power is removed. The multimeter has 14k-bytes of memory which are used for both states and subprograms. Each state occupies about 300 bytes. If no subprograms are in memory, the multimeter can store a maximum of 46 states. When subprogram/state memory becomes full, the multimeter generates the *Memory Error* (bit 7 in the error register).

Storing states

The SSTATE command stores the multimeter's present state with an identifying name. A state name may contain up to 10 characters. The name can be all alpha characters or a combination of alpha and numeric characters (the characters ? and _ can also be included in the name). You can also use an integer in the range of 0 to 127 as the name (this is primarily for front panel operation). When using an alphanumeric name, the first character must be alpha. Alpha or alphanumeric state names must not be the same as multimeter commands or parameters or the name of a stored subprogram. When using an integer state name, the multimeter assigns the prefix *STATE* to the integer when the state is stored. This differentiates an integer state name from an integer subprogram name. For example, a state stored with the name 8 will be recorded as *STATE8*. The state can be recalled later using either the name 8 or *STATE8*.

All states are stored in continuous memory (remain intact when power is removed). The multimeter compiles the state as it is stored. This means that when the state is recalled, the multimeter configures itself much faster than could be done by executing the individual commands that were used to create the state. To store the present multimeter state as a state named *ACST1*, send:

```
OUTPUT 722; "SSTATE ACST1"
```


Recalling states

The RSTATE command recalls a state from memory and configures the multimeter to the recalled state. For example, to recall state ACST1 send:

OUTPUT 722;"RSTATE ACST1"

From the front panel, you can view all stored state names by accessing the RSTATE command and pressing the up or down arrow key. Once you have found the correct state, press Enter to recall the state.

Deleting states

You can delete a single stored state using the PURGE command. For example, to purge the state ACST1, send:

OUTPUT 722;"PURGE ACST1"

You can also use the SCRATCH command to delete all stored states and all subprograms from memory.

Using the Input Buffer

In the multimeter's power-on/PRESET NORM state, the input buffer is disabled. This means the multimeter must process each GPIB command individually and wait until the command is executed before releasing the GPIB bus or accepting another command. In most cases, the controller must wait until the bus is released before it can continue, which ensures synchronization between the controller and the instrument. This is most noticeable on commands that take a long time to execute. For example, if you run the complete self-test from remote (TEST command), the multimeter does not release the GPIB bus until the self test is complete, approximately 50 seconds.

With the input buffer enabled, the multimeter temporarily stores commands in the buffer and immediately releases the GPIB bus. The multimeter then retrieves and executes the commands in the order received, one by one, from the input buffer. This allows the controller to perform other operations while the multimeter is executing commands. The following program enables the input buffer prior to executing the TEST command.

```
10 OUTPUT 722;"INBUF ON"  
20 OUTPUT 722; "TEST"  
30 END
```

The input buffer holds a maximum of 255 characters. If you send more characters than the input buffer can hold, the multimeter holds the bus until buffer space becomes available. When space is available, the remaining characters are accepted into the input buffer and the bus is released.

When using the input buffer, it may be necessary to know when all buffered commands have been executed. The multimeter provides this information by setting bit 4 (ready for instructions) in the status register (discussed next). If the status register is properly enabled, it drives the GPIB's SRQ (service request) line true. Your controller will acknowledge this if previously programmed to accept SRQ as an interrupt.

Using the Status Register

The status register monitors the following multimeter status information:

- Subprogram complete
- High or low limit exceeded
- SRQ command executed
- Power turned-on
- Ready for instructions
- Error
- Service requested
- Data available.

When one of these events occurs, it sets a corresponding bit, in the status register. The following list defines the meaning of each bit in the status register:

Bit 0 (weight = 1) Subprogram Complete--a stored subprogram has been executed.

Bit 1 (weight = 2) High or Low Limit Exceeded--one or more readings have exceeded the high/low limits specified for the Pass/Fail math operation. This bit applies to both real-time and post-process math. (See [Pass/Fail](#) in [Chapter 4](#).)

Bit 2 (weight = 4) SRQ Command Executed--the multimeter's SRQ command has been executed.

Bit 3 (weight = 8) Power-On--a power-on sequence has occurred.

Bit 4 (weight = 16) Ready for Instructions--the multimeter has completed execution of any previous commands and is ready to accept more commands. (When using TRIG SGL or TARM SGL to initiate a group of readings with the input buffer off, this bit can be used to monitor when all readings are complete.)

Bit 5 (weight = 32) Error--one or more errors have been logged in the error/auxiliary register. Refer to [Reading the error registers](#) earlier in this chapter for more information.

NOTE

You can prevent any or all errors from setting the error bit in the status register using the EMASK command. Refer to the EMASK command in [Chapter 6](#) for more information.

Bit 6 (weight = 64) Service Request--service is requested and the GPIB SRQ line is set true. This bit will be set when any other bit of the status register is set and has been enabled to assert SRQ by the RQS command. It is possible for bit 6 to be the only bit set such as when an error set a bit in the error register which, in turn, set bit 6. Later, the error register was read which removed the error bit but left bit 6 set,

Bit 7 (weight = 128) Data Available--a reading or query response is available in the output buffer.

Reading the status register

The STB? query command reads the status register and returns the weighted sum of all set bits. The STB? command does not clear the status register. The following program uses the STB? command to read the contents of the status register.

```
10 OUTPUT 722."STB?"
20 ENTER 722; A
30 PRINT A
40 END
```

For example, assume bit 3 (weight = 8) and bit 7 (weight = 128) are set. The above program returns the sum of the two weights (136).

The STB? command will never reveal bit 4 (Ready for Instructions) set because the multimeter is busy processing the STB? command and, therefore, is not ready. If you intend to monitor the ready bit, you must use the GPIB Serial Poll command to read the status register. If the SRQ line is true, the Serial Poll command clears all status register bits.* The SRQ line is also returned to false if bit 6 is cleared. If the SRQ line is false during Serial Poll, the register's contents are not changed. The following program shows how to read the status register using the Serial Poll command.

```
10 P=SPOLL(722)
20 DISP P
30 END
```

To clear the status register,^[1] send:

```
OUTPUT 722; "CSB"
```

[1] Bits 4, 5, and 6 are not cleared if the condition(s) that set the bit(s) still exist.

Interrupts

When a bit of the status register is set and has been enabled to assert SRQ (RQS command), the multimeter sets the GPIB SRQ line true. This can be used to alert the controller to interrupt its present operation and find out what service the multimeter requires. (Refer to your controller-operating manual for information on how to program it to respond to the interrupt.)

To allow any of the status register bits to set the SRQ line true, you must first enable the bit(s) with the RQS command. For example, suppose your application requires an interrupt when a high or low limit is exceeded (bit 1), power is cycled (bit 3), or when an error occurs (bit 5). The decimal equivalents of these bits are 2, 8, and 32, respectively. The decimal sum is 42. You can enable these bits to assert SRQ by sending:

```
OUTPUT 722;"RQS 42"
```

Now, whenever one of the events associated with bits 1, 3, or 5 occurs, it will set bit 6 in the status register and assert SRQ. Notice that the bits that are not enabled still respond to their corresponding conditions. They do not, however, set bit 6 or assert SRQ. The following program is an example of interrupts using Keysight Series 200/300 BASIC.

```
10 !HI/LO LIMIT EXCEEDED,ERROR, POWER CYCLED INTERRUPT
20 OUTPUT 722;"PRESET NORM"
30 OUTPUT 722; "CSB"
40 ON INTR 7 GOTO 90
50 ENABLE INTR 7;2
60 OUTPUT 722;"RQS 42;MATH PFAIL;SMATH MIN -5;SMATH MAX 5"
70 OUTPUT 722;"TRIG AUTO"
80 GOTO 80
90 OUTPUT 722; "STB?"
100 ENTER 722;A
110 IF BINAND (A,2) THEN PRINT "HI/LO LIMIT EXCEEDED"
120 IF BINAND (A,8) THEN PRINT "POWER WAS CYCLED"
130 IF BINAND (A,32) THEN PRINT "ERROR OCCURRED"
140 END
```

3 Configuring for Measurements

Line 20 presets the multimeter, which suspends triggering. Line 30 clears the status register. Line 40 instructs the controller to go to line 90 should an interrupt occur. Line 50 enables SRQ interrupts on the GPIB interface. Line 60 enables the hi/lo limit, power-on, and error bits to assert SRQ. Line 60 also enables the real-time pass/fail math operation with the values of -5 for the low limit and +5 for the hi limit. Line 70 enables automatic triggering. Line 80 causes the controller to wait for an interrupt. Lines 90 through 130 read the status register and print which condition(s) caused the interrupt.

4 Making Measurements

Introduction	124
Triggering Measurements	125
Reading Formats	140
Using Reading Memory	144
Sending Readings Across the Bus	149
Increasing the Reading Rate	156
The EXTOUT Signal	168
Math Operations	175

Introduction

This chapter discusses the methods for triggering measurements, the reading formats, how to use reading memory, and how to transfer readings across the bus. This chapter also discusses how to increase the reading rate and GPIB bus transfer speed, how to measure the reading rate, how to use the multimeter's EXTOUT signal, and how to use the math operations.

Triggering Measurements

Before the multimeter will take readings, three separate events must occur in the proper order. These events are (1) the trigger arm event, (2) the trigger event, and (3) the sample event. Sub-sampling (discussed in [Chapter 5](#)) and multiple trigger arming (discussed in this chapter) are the only exceptions to this triggering hierarchy. As shown in [Figure 4-1](#), when all three events have occurred in the order listed, the multimeter begins to make the specified reading(s). In the power-on state, the multimeter is configured so that it makes readings automatically; that is, all three events are set to AUTO. For most applications, you will need to use only one or two of these events and leave the other event(s) set to AUTO. This section describes the various events that can be used to satisfy the trigger arm, trigger, and sample event requirements and contains examples showing how to use these events.

NOTE

The examples in this manual are intended for Hewlett-Packard Series 200/300 computers using BASIC language. They assume a GPIB interface select code of 7 and a device address of 22 resulting in a combined GPIB address of 722. Some of the examples in this section store readings in memory while others transfer readings to the controller. Reading destination is discussed in detail later in this chapter under [Using Reading Memory](#) and [Sending Readings Across the Bus](#).

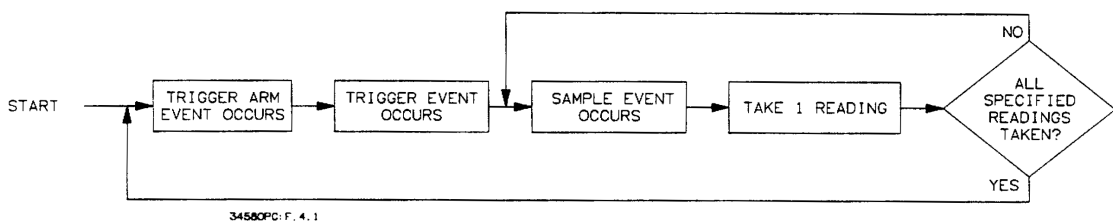


Figure 4-1 Triggering hierarchy

The trigger arm event

When the specified trigger arm event occurs, it arms the multimeter's triggering mechanism. That is, the trigger arm event enables a subsequent trigger event. You specify the trigger arm event using the TARM command.

The trigger event

When the specified trigger event occurs (and the trigger arm event has already occurred), it enables a subsequent sample event. You specify the trigger event using the TRIG command.

The sample event

When the sample event occurs (and the trigger arm and trigger events have already occurred), the multimeter makes a reading. The multimeter will then make one reading per sample event until the specified number of readings are taken. The first parameter of the NRDGS (number of readings) command specifies how many readings are to be taken per trigger event. The second parameter specifies the event (sample event) that initiates each reading.

Event choices

You can select from a variety of events to use as the trigger arm, trigger, and sample events. [Table 4-1](#) describes the event parameters and shows the commands to which they apply.

Table 4-1 Event parameters

Event parameter	Used with: TARM	Used with: TRIG	NRDGS	Event description
AUTO	✓	✓	✓	Occurs automatically (whenever required)
EXT	✓	✓	✓	Occurs on negative edge transition on the multimeter's external trigger input
HOLD	✓	✓		Suspends measurements
LEVEL ^[a]		✓	✓	Occurs when the specified voltage is reached on the specified slope of the input signal

Table 4-1
Event parameters (continued)

Event parameter	Used with: TARM	Used with: TRIG	NRDGS	Event description
LINE ^[b]		✓	✓	Occurs when the power line voltage crosses zero volts
SGL	✓	✓		Occurs once (upon receipt of TARM SGL or TRIG SGL command, then becomes HOLD)
SYN	✓	✓	✓	Occurs when the multimeter's output buffer is empty, reading memory is off or empty, and the controller requests data
TIMER ^[b]			✓	Occurs automatically with a time interval between readings

[a] The LEVEL trigger or sample event can be used only for DC voltage or direct-sampled digitizing.

[b] The TIMER or LINE event cannot be used for AC or AC+DC voltage measurements using the synchronous or random method, or for frequency or period measurements.

Making continuous readings

In the power-on state, the multimeter's trigger arm, trigger, and sample events are all set to AUTO. This causes the multimeter to take readings continuously. Typically, continuous readings should be suspended before configuring the multimeter using either the TARM HOLD or TRIG HOLD command or by setting the multimeter to one of the PRESET states (see [Suspending readings](#) in [Chapter 3](#)). After configuring the multimeter, you can resume continuous readings (assuming the other triggering events have not been changed) by sending:

```

OUTPUT 722;"TARM AUTO"
!Resumes readings suspended by TARM HOLD, PRESET FAST, or PRESET DIG
or
OUTPUT 722; "TRIG AUTO"
!Resumes readings suspended by TRIG HOLD or PRESET NORM
  
```

Making single readings

The NRDGS command specifies the number of readings made per trigger event and the sample event that initiates each reading. In the power-on, RESET, PRESET NORM, or PRESET FAST state, the number of readings per trigger is set to 1 and the sample event is AUTO (NRDGS 1,AUTO). In any of these states, you can initiate a single reading by executing the TARM SGL or TRIG SGL command (depending on which event, if any, is suspending readings). For example, the following program resets the multimeter and suspends readings by setting the trigger arm event to HOLD. The configuration is changed (lines 30-50) and line 60 initiates a single reading, which is transferred to the controller and displayed. After the single reading, the trigger arm event becomes HOLD, which suspends readings.

```
10 OUTPUT 722;"RESET"!RESET, ALL TRIGGERING EVENTS AUTO
20 OUTPUT 722;"TARM HOLD"!SUSPEND READINGS
30 OUTPUT 722;"DCV 10"!DC VOLTAGE, 10 V RANGE
40 OUTPUT 722;"NPLC 1"!1 PLC INTEGRATION TIME
50 OUTPUT 722;"AZERO OFF"!AUTOZERO OFF
60 OUTPUT 722;"TARM SGL"!TRIGGER 1 READING
70 ENTER 722;A!ENTER READING
80 PRINT A!PRINT READING
90 END
```

In the PRESET NORM state, readings are suspended because the trigger event is set to SYN (the SYN event is discussed later in this chapter). In this state, you can initiate a single reading using the TRIG SGL command. For example, in the following program, line 10 suspends readings by setting the trigger event to SYN. Line 20 initiates a single reading and the reading is transferred to the controller and displayed. Following execution of the TRIG SGL command, the trigger event becomes HOLD which suspends readings.

```
10 OUTPUT 722;"PRESET NORM"!TARM AUTO, TRIG SYN, NRDGS 1,AUTO
20 OUTPUT 722;"TRIG SGL"!GENERATE SINGLE TRIGGER
30 ENTER 722;A!ENTER READING
40 PRINT A!PRINT READING
50 END
```

Making multiple readings

You can use the NRDGS command to specify more than one reading per trigger event. For example, the following program takes 10 readings per trigger event (one reading is taken per sample event) and transfers them to the controller. Notice that the input buffer is enabled (line 40). This is because, with the input buffer disabled, the SGL event (line 60) holds the GPIB bus until all specified readings are complete. This would prevent line 70 from transferring all but the last reading to the controller. Enabling the input buffer prevents the TRIG SGL command from holding the bus and allows each reading to be transferred as it becomes available.

```
10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(10)!DIMENSION ARRAY FOR 10 READINGS
30 OUTPUT 722;"PRESET NORM"!TARM AUTO, TRIG SYN, DCV AUTORANGE
40 OUTPUT 722;"INBUF ON"!ENABLE INPUT BUFFER
50 OUTPUT 722;"NRDGS 10, AUTO"!10 READINGS/TRIGGER, AUTO SAMPLE EVENT
60 OUTPUT 722;"TRIG SGL"!TRIGGER READINGS
70 ENTER 722;Rdgs(*)!ENTER READINGS
80 PRINT Rdgs(*)!DISPLAY READINGS
90 END
```

Multiple trigger arming

The second parameter of the TARM command allows you to specify multiple trigger arming. When multiple trigger arming is specified, a single occurrence of the trigger arm event arms the multimeter the specified number of times. (The trigger arm event must be SGL for multiple arming.) This causes the multimeter to make multiple groups of readings as shown in [Figure 4-2](#).

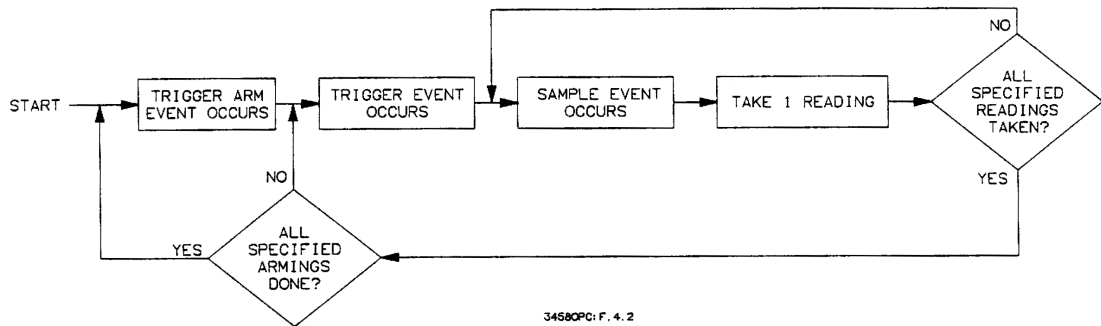


Figure 4-2 Multiple trigger arming

In the following program, the NRDGS command selects 10 readings per trigger event. The second parameter of the TARM command specifies 5 armings. This program stores 5 groups of ten readings for a total of 50 readings.

```

10  OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20  DIM Rdgs(50)!DIMENSION ARRAY FOR 50 READINGS
30  OUTPUT 722;"PRESET NORM"!TARM AUTO, TRIG SYN, DCV AUTORANGE
40  OUTPUT 722;"TARM HOLD"!HOLD TRIGGER ARM EVENT
50  OUTPUT 722;"TRIG AUTO"!AUTO TRIGGER EVENT
60  OUTPUT 722;"INBUF ON"!ENABLE INPUT BUFFER
70  OUTPUT 722;"NRDGS 10,AUTO"!10 READINGS/TRIGGER, AUTO SAMPLE EVENT
80  OUTPUT 722;"TARM SGL,5"!ARM TRIGGERING 5 TIMES
90  ENTER 722;Rdgs(*)!ENTER READINGS
100 PRINT Rdgs(*)!PRINT READINGS
110 END

```

Making synchronous readings

You can synchronize the multimeter to the controller by setting the trigger arm, trigger, and/or sample event to synchronous (SYN). The synchronous event occurs whenever the multimeter's output buffer is empty, reading memory is off or empty, and the controller requests data. This means that measurements are made whenever the controller wants them. This is a very important feature for remote operation, especially when the multimeter is in the high-speed mode.

In the high-speed mode, the synchronous event ensures that the controller is ready to accept readings and will not slow the reading rate. Refer to [High-speed](#)

mode later in this chapter for more information. In the following program, the PRESET NORM command sets the trigger event to synchronous. Line 40 specifies 15 readings per synchronous trigger event. Line 50 requests data from the multimeter. This satisfies the synchronous trigger event and initiates the readings. Notice that line 50 requests data from the multimeter 15 times. When multiple readings are specified and SYN is used as the trigger or trigger arm event, the multimeter does not recognize the multiple data requests as individual SYN events. That is, in this program the SYN trigger event occurs once, not 15 times.

```
10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs (15)!DIMENSION ARRAY FOR 15 READINGS
30 OUTPUT 722;"PRESET NORM"!TARM AUTO, TRIG SYN, DCV AUTORANGE, MEM OFF
40 OUTPUT 722;"NRDGS 15,AUTO"!15 READINGS/TRIGGER, AUTO SAMPLE EVENT
50 ENTER 722;Rdgs(*)!GENERATE SYN EVENT, ENTER READINGS
60 PRINT Rdgs(*)!DISPLAY READINGS
70 END
```

The following program uses the synchronous event as the sample event. Line 60 requests data from the multimeter 15 times. When SYN is used as the sample event, each request for data is recognized as a SYN event. That is, in this program the SYN event occurs 15 times.

```
10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(15)!DIMENSION ARRAY FOR 15 READINGS
30 OUTPUT 722;"PRESET NORM"!TARM AUTO, TRIG SYN, DCV AUTORANGE
40 OUTPUT 722;"NRDGS 15,SYN"!15 READINGS PER TRIGGER, SYN SAMPLE EVENT
50 OUTPUT 722;"TRIG AUTO"!AUTO TRIGGER EVENT
60 ENTER 722;Rdgs(*)!SYN EVENT, ENTER EACH READING
70 DISP Rdgs(*)!PRINT READINGS
80 END
```

Making timed readings

When making multiple readings per trigger, you can use the TIMER sample event to place a specified time interval between readings. This interval is the amount of time from the beginning of one reading to the beginning of the next reading. You specify the interval in seconds using the TIMER command. (If the specified interval is less than the time required to make each reading, the multimeter generates the TRIG TOO FAST error). The following program specifies 8 readings per trigger with 1 second between readings (this is shown in [Figure 4-3](#)).

```
10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(8)!DIMENSION ARRAY FOR 8 READINGS
```

```

30 OUTPUT 722;"PRESET NORM"!TARM AUTO, TRIG SYN, DCV AUTORANGE
40 OUTPUT 722;"NRDGS 8, TIMER"!8 READINGS/TRIGGER, TIMER SAMPLE EVENT
50 OUTPUT 722;"TIMER 1"!1 SECOND TIMER INTERVAL
60 ENTER 722;Rdgs(*)!SYN EVENT,ENTER EACH READING
70 PRINT Rdgs(*)!PRINT READINGS
80 END

```

You can also use the SWEEP command to replace the NRDGS n,TIMER command and the TIMER command. The SWEEP command's first parameter specifies the interval between readings and its second parameter specifies the number of readings. (The SWEEP and NRDGS commands are interchangeable: the multimeter uses whichever was specified last in the programming.) For example, the following program also takes 8 readings with a 1 second interval between readings (this is shown in [Figure 4-3](#)).

```

10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(8)!DIMENSION ARRAY FOR 8 READINGS
30 OUTPUT 722;"PRESET NORM"!TARM AUTO, TRIG SYN, DCV AUTORANGE
40 OUTPUT 722;"SWEEP 1,8"!1 SECOND INTERVAL, 8 READINGS/TRIGGER
50 ENTER 722;Rdgs(*)!SYN EVENT,ENTER EACH READING
60 PRINT Rdgs(*)!PRINT READINGS 80 END
70 END

```

NOTE

When using the TIMER sample event or the SWEEP command, autorange is disabled. You cannot use TIMER or SWEEP for AC or AC+DC voltage measurements using the synchronous or random methods (SETACV SYNC or RNDM), or for frequency or period measurements.

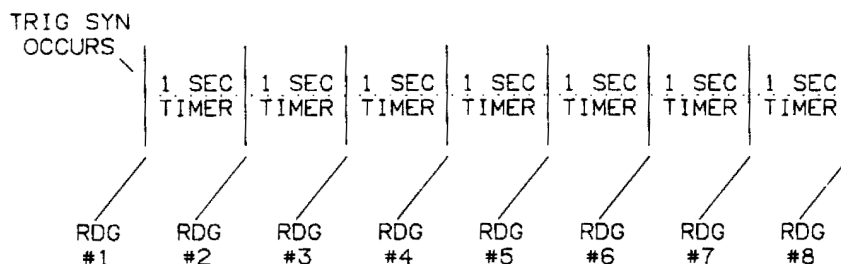


Figure 4-3 TIMER or SWEEP interval

Making delayed readings

The DELAY command allows you to specify a time interval that is inserted between the trigger event and the first sample event. For example, in the following program, the specified delay interval is 2 seconds and the SWEEP interval is 1 second. Line 40 specifies 8 readings per trigger event. [Figure 4-4](#) shows that the delay occurs between the trigger event (TRIG SGL) and the first reading. The SWEEP interval then occurs between each successive reading. In this example, the amount of time added to the total measurement is 9 seconds.

```

10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(8)!DIMENSION ARRAY FOR READINGS
30 OUTPUT 722;"PRESET NORM"!TARM AUTO, TRIG SYN, DCV AUTORANGE
40 OUTPUT 722;"SWEEP 1,8"!1 SECOND INTERVAL, 8 READINGS/TRIGGER
50 OUTPUT 722;"DELAY 2"!2 SECOND DELAY
60 ENTER 722;Rdgs(*)!ENTER READINGS
70 PRINT Rdgs(*)!PRINT READINGS
80 END

```

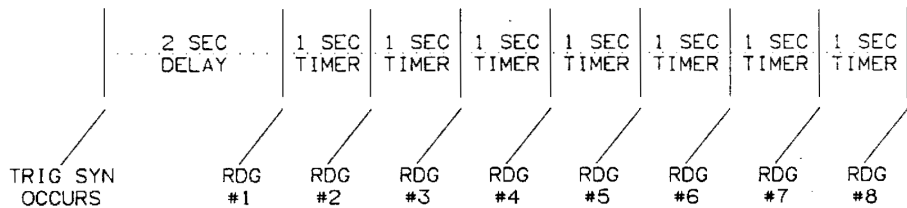


Figure 4-4 DELAY with SWEEP (or TIMER)

Default delays

If you have not specified a delay interval, the multimeter automatically determines a delay time (default delay time) based on the present measurement function, range, resolution, and the AC bandwidth setting. This delay time is actually the settling time allowed before readings, which ensures accurate measurements. The default delay time is updated automatically whenever the function range, resolution, or AC bandwidth changes. However, once you specify a delay time value, the value does not change until you execute RESET or a PRESET command, cycle power, specify another delay value, or default the delay parameter (DELAY -1 command which returns to the automatic delay). The following program uses

the DELAY? query command to respond with the delay time for the PRESET NORM state.

```
10 OUTPUT 722;"PRESET NORM"
20 OUTPUT 722;"DELAY?"
30 ENTER 722;A$
40 PRINT A$
50 END
```

External triggering

The external (EXT) event allows the multimeter to be triggered from an external source. This event can be used as the trigger arm, the trigger event, and/or the sample event. The EXT event occurs on a negative edge transition of a TTL pulse applied to the multimeter's rear panel Ext Trig connector. The minimum pulse width recognized is 250 ns. The bandwidth of the external trigger circuitry is 5 MHz.

The following program uses the EXT event as the trigger event. The sample event is AUTO; the number of readings per trigger event is set to 1. Upon the arrival of a negative edge transition on the Ext Trig terminal, the multimeter takes a reading, which is transferred, to the controller. A second negative edge transition initiates the second reading, which is transferred to the controller. This sequence continues until all 20 readings are completed and transferred to the controller.

```
10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(20)!DIMENSION ARRAY FOR READINGS
30 OUTPUT 722;"PRESET NORM"!TARM AUTO,TRIG SYN, NRDGS 1,AUTO,
50 OUTPUT 722;"TRIG EXT"!TRIGGER EACH READING
60 ENTER 722;Rdgs(*)!ENTER READINGS
70 PRINT Rdgs(*)!PRINT READINGS
80 END
```

The following example uses EXT as the sample event. The trigger event is synchronous (selected by the PRESET NORM command). The number of readings per trigger event is set to 10. When the controller executes line 50, the synchronous event occurs which enables the sample event (EXT). Upon the arrival of a negative edge transition on the Ext Trig terminal, the multimeter takes a single reading, which is transferred, to the controller. A second negative edge transition initiates the second reading, which is transferred to the controller. This sequence continues until all 10 readings are completed and transferred to the controller.

```
10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(10)!DIMENSION ARRAY FOR READINGS
30 OUTPUT 722;"PRESET NORM"!TARM AUTO, TRIG SYN, DCV AUTORANGE
40 OUTPUT 722;"NRDGS 10,EXT"!10 READINGS/TRIGGER, EXTERNAL SAMPLE EVENT
50 ENTER 722;Rdgs(*)!ENTER READINGS
60 PRINT Rdgs(*)!PRINT READINGS
70 END
```

NOTE

Refer to the “EXTOUT Signal” later in this chapter, for examples showing how to synchronize the multimeter to an external scanning device.

External trigger buffering

Trigger buffering corrects for an error (TRIGGER TOO FAST) that can occur when using the external (EXT) trigger arm, trigger, or sample event. With trigger buffering disabled, any external trigger signal that occurs during a reading generates the TRIGGER TOO FAST error and the trigger(s) are ignored. With trigger buffering enabled, the first external trigger that occurs during a reading is stored and no error is generated by this or any successive triggers. After the reading is complete, the stored trigger satisfies the EXT event if the multimeter is so programmed. Trigger buffering is useful when you are using an external scanning device synchronized to the multimeter's EXTOUT signal using the input complete (ICOMP) event. Since the ICOMP pulse occurs before each reading is finished, it is possible for the scanner to close the next channel and generate its channel closed pulse (which is used to trigger the multimeter) before the reading is complete. (Refer to [Input complete](#), later in this chapter, for more information.) In the multimeter's power-on state, trigger buffering is disabled. To enable trigger buffering, send:

```
OUTPUT 722;"TBUFF ON"
```

To disable trigger buffering, send:

```
OUTPUT 722; "TBUFF OFF"
```

Event combinations

You can specify many combinations of the trigger arm, trigger, and sample events to suit your application. Table 4-2 shows, all possible combinations of these events and describes the resultant triggering sequence for each.

Table 4-2 Event combinations

Trigger arm event	Trigger event	Sample event	Description
AUTO	AUTO	Any	One reading is taken per sample event (if the sample event is AUTO, readings are taken continuously).
AUTO	EXT	AUTO, EXT, TIMER, LINE, LEVEL	After a negative edge transition on the Ext Trig input, one reading is taken per sample event until the specified number of readings are completed.
AUTO	EXT	SYN	Illegal
AUTO	LEVEL	AUTO, EXT, TIMER, LEVEL	After the LEVEL event ^[a] occurs, one reading is taken per sample event, until the specified number of readings are completed.
AUTO	LEVEL	SYN, LINE	Illegal
AUTO	LINE	AUTO, EXT, TIMER, LINE	After the power line voltage crosses zero volts, one reading is taken per sample event until the specified number of readings are completed.
AUTO	LINE	SYN, LEVEL	Illegal
AUTO	SGL	Any	After executing the TRIG SGL command, one reading is taken per sample event until the specified number of readings are completed. The trigger event then becomes HOLD. When using the SYN sample event, the input buffer must be enabled or you must suppress cr lf when sending the TRIG SGL command.
AUTO	SYN	SYN	After the controller requests data, ^[b] both SYN events are satisfied and the first reading is taken. One reading is then taken per SYN event until the specified number of readings are completed.
AUTO	SYN	AUTO, EXT, LEVEL, LINE, TIMER	After the controller requests data, ^[b] one reading is taken per sample event until the specified number of readings are completed.

Table 4-2 Event combinations (continued)

Trigger arm event	Trigger event	Sample event	Description
EXT	AUTO	Any	After a negative edge transition on the Ext Trig input, one reading is taken per sample event until the specified number of readings are completed.
EXT	EXT	AUTO, EXT, TIMER, LINE, LEVEL	After two negative edge transitions on the Ext Trig input, one reading is taken per sample event until the specified number of readings are completed.
EXT	EXT	SYN	Illegal
EXT	LEVEL	AUTO, EXT, TIMER, LEVEL	After a negative edge transition on the Ext Trig input followed by the occurrence of the LEVEL event ^[a] , one reading is taken per sample event until the specified number of readings are completed.
EXT	LEVEL	SYN, LINE	Illegal
EXT	LINE	AUTO, EXT, TIMER, LINE	After a negative edge transition on the Ext Trig input followed by the power line voltage crossing zero volts, one reading is taken per sample event until the specified number of readings are completed.
EXT	LINE	SYN, LEVEL	Illegal
EXT	SGL	ANY	Illegal
EXT	SYN	SYN	After a negative edge transition on the Ext Trig input followed by the controller requesting data ^[b] (which satisfies both SYN events), the first reading is taken. One reading is then taken per SYN event until the specified number of readings are completed.
EXT	SYN	AUTO, EXT, TIMER, LINE, LEVEL	After a negative edge transition on the Ext Trig input, followed by the controller requesting data ^[b] one reading is taken per sample event, until the specified number of readings are completed.
HOLD	Any	Any	No readings taken until the trigger arm event is changed.
AUTO, EXT, SGL, SYN	HOLD	Any	No readings taken until the trigger event is changed. When using the SGL trigger arm event and the SYN sample event, the input buffer must be enabled or you must suppress cr lf when sending the TARM SGL command.

Table 4-2 Event combinations (continued)

Trigger arm event	Trigger event	Sample event	Description
SGL	AUTO	Any	After executing the TARM SGL command, one reading is taken per sample event until the specified number of readings are completed. The trigger arm event then becomes HOLD. When using the SYN sample event, the input buffer must be enabled or you must suppress cr lf when sending the TARM SGL command.
SGL	EXT	AUTO, EXT, TIMER, LINE, LEVEL	After executing the TARM SGL command followed by a negative edge transition on the Ext Trig input, one reading is taken per sample event, until the specified number of readings are completed. The trigger arm, event then becomes HOLD.
SGL	EXT	SYN	Illegal
SGL	LEVEL	AUTO, EXT, TIMER, LEVEL	After executing the TARM SGL command followed by the occurrence of the LEVEL event, ^[a] one reading is taken per sample event until the specified number of readings are completed. The trigger arm event then becomes HOLD.
SGL	LEVEL	SYN, LINE	Illegal
SGL	LINE	AUTO, EXT, TIMER, LINE	After executing the TARM SGL command followed by the power line voltage crossing zero volts, one reading is taken per sample event until the specified number of readings are completed. The trigger arm event then becomes HOLD.
SGL	LINE	SYN, LEVEL	Illegal
SGL	SGL	Any	Illegal
SGL	SYN	SYN	After executing the TARM SGL command, followed by the controller requesting data ^[b] , which satisfies both SYN events, the first reading is taken. One reading is then taken per SYN event until the specified number of readings are completed. ^[c] The trigger arm event then becomes HOLD.
SGL	SYN	AUTO, EXT, TIMER, LINE, LEVEL	After executing the TARM SGL command, followed by the controller requesting data, ^[b] one reading is taken per sample event until the specified number of readings are completed. ^[c] The trigger arm event then becomes HOLD.

Table 4-2 Event combinations (continued)

Trigger arm event	Trigger event	Sample event	Description
SYN	AUTO	SYN	After the controller requests data, ^[b] (which satisfies both SYN events) the first reading is taken. One reading is then taken per SYN event until the specified number of readings are completed.
SYN	AUTO	AUTO, EXT, TIMER, LINE, LEVEL	After the controller requests data, ^[b] one reading is taken per sample event until the specified number of readings are completed.
SYN	EXT	AUTO, EXT, TIMER, LINE, LEVEL	After the controller requests data, ^[b] followed by a negative edge transition on the Ext Trig input, one reading is taken per sample event until the specified number of readings are completed.
SYN	EXT	SYN	Illegal
SYN	LEVEL	AUTO, EXT, TIMER, LEVEL	After the controller requests data, ^[b] followed by the occurrence of the LEVEL event, ^[a] one reading is taken per sample event until the specified number of readings are completed
SYN	LEVEL	SYN, LINE	Illegal
SYN	LINE	AUTO, EXT, TIMER, LINE	After the controller requests data, ^[b] followed by the power line voltage crossing zero volts, one reading is taken per sample event until the specified number of readings are completed.
SYN	LINE	SYN, LEVEL	Illegal
SYN	SGL	Any	Illegal
SYN	SYN	SYN	After the controller requests data, ^[b] all three events are satisfied and the first reading is taken. One reading is then taken per SYN event until the specified number of readings are completed.
SYN	SYN	AUTO, EXT, TIMER, LINE, LEVEL	After the controller requests data, ^[b] both SYN events are satisfied. One reading is then taken per sample event until the specified number of readings are completed.

[a] The LEVEL event occurs when the specified voltage is reached on the specified slope of the input signal. The LEVEL trigger event or sample event can only be used for DC voltage or direct-sampled measurements.

[b] The output buffer must be empty and reading memory must be OFF or empty for the SYN event to occur.

[c] The input buffer must be enabled or you must suppress cr lf when sending the TARM SGL command.

Reading Formats

This section discusses the ASCII, single integer (SINT), double integer (DINT), single real (SREAL), and double real (DREAL) formats that can be used for storing readings or for outputting readings on the GPIB. Storing readings in memory is described later in this chapter under [Using Reading Memory](#); outputting readings on the GPIB is discussed later in this chapter under [Sending Readings Across the Bus](#).

ASCII

The ASCII format is 15 bytes per reading encoded in scientific notation in standard units of volts, amps, ohms, hertz, or seconds as follows:

SD.DDDDDDDDESDD

Where:

S = sign (+ or -)

D = 0-9

E = delimiter between mantissa and base 10 exponent

Single and double integer

The single integer (SINT) format has 2 bytes per reading and the double integer (DINT) format has 4 bytes per reading. Both formats use two's complement coding.

NOTE

When using the SINT or DINT memory/output format, the multimeter applies a scale factor to the readings. The scale factor is based on the multimeter's measurements function, range, A/D converter setup, and enabled math operations. You should not use the SINT or DINT format for frequency or period measurements; when a real-time or post-process math operation is enabled (except STAT or PFAIL); or when autorange is enabled.

Two's complement binary coding

Two's complement binary coding is a method that allows a binary number to represent both positive and negative integers. Two's complement coding is done by changing the sign and, in effect, the decimal equivalent of the most significant bit (MSB). When the MSB is set (1), in a 1 byte two's complement number, its value is $1 \times -(2^7) = -128$. When the MSB is reset (0), its value is $0 \times -(2^7) = 0$. Note that the range of an 8 bit, 1 byte two's complement number is -128 to 127, not 0 to 255.

The following example resolves the decimal equivalent of this two's complement word:

10110101 10010110

This two's complement word is equivalent to:

$$-(2^{15}) + 2^{13} + 2^{12} + 2^{10} + 2^8 + 2^7 + 2^4 + 2^2 + 2^1$$

Which evaluates to: -19050

Single real

The single real (SREAL) format conforms to IEEE-754 specifications. This format has 32 bits, 4 bytes per reading as follows:

S	EEE	EEEE	E	MMM	MMMM	MMMM	MMMM	MMMM	MMMM
byte 0		byte 1		byte 2		byte 3			

Where:

S = sign bit (1 = negative 0 = positive)

E = base two exponent biased by 127 (to “decode” these 8 bits, subtract 127 from their decimal equivalent).

M = mantissa bits (those right of the radix point). There is an implied most significant bit (MSB) to the left of the radix point. This bit is always assumed to be “1”. This provides an effective precision of 24 bits with the least significant bit (right most) weighted 2^{-23} . Another way to evaluate this mantissa is to convert these 24 bits (MSB assumed “1”) to an integer and then multiply by 2^{-23} .

The value of a number in the SREAL format is calculated by:

$$(-1)^S \times (\text{mantissa}) \times 2^{(\text{exponent})}$$

SREAL example

This example resolves the decimal equivalent of the following SREAL formatted number:

SEEEEEEE EMMMMMMM MMMMMMMM MMMMMMMM

10111011 11001000 01001000 10010000

The sign bit “S” is set “1,” this indicates that the number is negative.

The base two's exponent (01110111) evaluates to:

$$2^6 + 2^5 + 2^4 + 2^2 + 2^1 + 2^0 = 119$$

Since the exponent is biased by 127, the real value is:

$$\text{exponent} - 127 = 119 - 127 = -8$$

The mantissa [1.10010000100100010010000 (MSB assumed “1”)] evaluates to:

$$1 + 2^{-1} + 2^{-4} + 2^{-9} + 2^{-12} + 2^{-16} + 2^{-19} = 1.56471443177$$

Evaluating the mantissa at the byte level instead of the bit level:

byte 1 byte 2 byte 3 = byte 1 byte 2 byte 3

11001000 01001000 10010000 200 72 144

$$\text{mantissa} = 200 \times 2^{-7} + 72 \times 2^{-15} + 144 \times 2^{-23} = 1.56471443177$$

or

$$\text{mantissa} = (200 \times 2^{16} + 72 \times 2^8 + 144) \times 2^{-23} = 1.56471443177$$

The SREAL number is then calculated by:

$$-1 \times 2^{-8} \times 1.56471443177 = -6.1121657491\text{E-}3$$

Double real

The double real (DREAL) format conforms to IEEE-754 specifications and contains 64 bits (8 bytes) per reading as follows:

byte 0	byte 1	byte 2	byte 3
S EEE EEEE	EEEE MMMM	MMMM MMMM	MMMM MMMM
byte 4	byte 5	byte 6	byte 7
MMMM MMMM	MMMM MMMM	MMMM MMMM	MMMM MMMM

Where:

S = sign bit (1 = negative 0 = positive)

E = base two exponent biased by 1023 (to decode these 11 bits, subtract 1023 from their decimal equivalent).

M = mantissa bits (those right of the radix point). There is an implied most significant bit (MSB) to the left of the radix point. This bit is always "1". This provides an effective precision of 53 bits with the least significant bit (right most) weighted 2^{-52} . Another way to evaluate this mantissa is to convert these 53 bits (MSB = "1") to an integer and then multiply by 2^{-52} .

The value of a number in the DREAL format is calculated by:

$$(-1)^S \times (\text{mantissa}) \times 2^{(\text{exponent})}$$

Using Reading Memory

The multimeter stores readings in memory whenever readings are being taken and reading memory is enabled. Reading memory has a FIFO (first-in-first-out) mode and a LIFO (last-in-first-out) mode. In the FIFO mode, the first reading stored is the first reading returned when you recall readings without specifying reading numbers (implied read method which is discussed later in this chapter). If you fill the reading memory in the FIFO mode, all stored readings remain intact and new readings are not stored.

In the LIFO mode, the last reading stored is the first reading returned when you recall readings without specifying reading numbers. If you fill reading memory in the LIFO mode, the oldest readings are replaced by the newest readings. You enable reading memory and specify the mode using the MEM command. (Specifying a reading memory mode erases any previously stored readings.) For example, to specify reading memory using the LIFO mode, send:

OUTPUT 722."MEM LIFO"

The multimeter is now enabled to store readings. After storing readings, you can disable reading memory and leave all stored readings intact by sending:

OUTPUT 722;"MEM OFF"

Later, you can resume the previous mode to store additional readings without clearing any stored readings by sending:

OUTPUT 722;"MEM CONT"

Memory formats

Readings can be stored in one of five formats: ASCII, single integer (SINT), double integer (DINT), single real (SREAL), or double real (DREAL). The memory space required for each format is:

ASCII - 16 bytes per reading^[1]
SINT - 2 bytes per reading
DINT - 4 bytes per reading
SREAL - 4 bytes per reading
DREAL - 8 bytes per reading

[1] The ASCII format is actually 15 bytes for the reading plus 1 byte per reading for a null character which is used to separate stored ASCII readings only.

To determine how many readings can be stored using a particular format, divide the reading memory size (first response returned by the MSIZE? command) by the number of bytes per reading shown above.

- Single Integer (SINT) or Double Integer (DINT) Use the SINT memory format when making low-resolution measurements (3.5 or 4.5 digits) at the fastest possible rate on a fixed range (autorange disabled). (Since the SINT format is only 2 bytes per reading, you can store more readings using SINT than in any other memory format.) Use the DINT memory format when making high-resolution measurements (5.5 digits or greater) at the fastest possible rate on a fixed range.

NOTE

When using the SINT or DINT memory format, the multimeter applies a scale factor to the readings. The scale factor is based on the multimeter's configuration (measurement function, range, A/D converter setup, and enabled math operations). When recalling readings, the multimeter calculates the scale factor based on its present configuration. If the configuration was changed since the readings were stored, a different scale factor may be used which produces incorrect readings. When recalling stored readings, it is very important that the multimeter be configured as it was when the readings were stored. You should not use the SINT or DINT format for frequency or period measurements; when a realtime or post-process math operation is enabled (except STAT or PFAIL); or when autorange is enabled.

- Single Real (SREAL) or Double Real (DREAL) Unlike the SINT and DINT formats, readings stored in SREAL or DREAL format are not scaled and can be used with any measurement function/multimeter configuration. (Since there is no scale factor, the SREAL and DREAL formats are ideal when auto ranging and/or a math function is enabled). Use the SREAL format for measurements with ≤ 6.5 digits of resolution. Use the DREAL format for measurements with > 6.5 digits of resolution.
- ASCII This memory format can be used for any measurement function/multimeter configuration. Since ASCII has the greatest number of bytes per reading, you should use it only when the output format is ASCII, measurement speed is not critical, and the number of readings to be stored is not great.

The MFORMAT command specifies the reading memory format (the power-on and default format is SREAL). For example, to select the single integer format, send:

OUTPUT 722; "MFORMAT SINT"

Overload indication

The multimeter indicates an overload condition (input greater than the present range can measure) by storing the value $\pm 1\text{E}+38$ in reading memory instead of a reading. When overload values are recalled to the display, the value $\pm 1\text{E}+38$ is displayed. When overload values are transferred from reading memory to the GPIB output buffer, they are converted to the overload numbers for the specified output format. Refer to [Sending Readings Across the Bus](#) later in this chapter for more information.

Recalling readings

You can recall readings from memory using the reading number or by a method called “implied read”. Regardless of the specified reading memory format, recalled readings are output in the format specified in the OFORMAT command (refer to [Sending Readings Across the Bus](#) later in this chapter for more information). Before recalling readings, you may want to determine the number of readings stored. This can be done using the MCOUNT? query command. The following program returns the total number of stored readings.

```
10 OUTPUT 722;"MCOUNT?"
20 ENTER 722;A
30 PRINT A
40 END
```

Using reading numbers

The multimeter assigns a number to each reading in reading memory. The most recent reading is assigned the lowest number (1) and the oldest reading is assigned the highest number. Reading numbers are always assigned in this manner regardless of whether the LIFO or FIFO mode is used. The RMEM command allows you to use the reading number(s) to copy a reading or group of readings from memory to the output buffer. The RMEM command does not destroy readings in memory: it merely copies the reading(s) to the output buffer.

The RMEM command turns reading memory OFF. This means all previously stored readings remain intact and new readings are not stored. The first parameter in the RMEM command specifies the beginning reading (first parameter). The second parameter (count) specifies the number of readings to be recalled, starting with first. The third parameter (record) specifies the record from which to recall readings. Records correspond to the number of readings specified in the NRDGS or SWEEP command. For example, if you have specified four readings in the

NRDGS command, each record in reading memory contains four readings. The following program specifies 10 readings per trigger (NRDGS 10) and uses the TARM SGL command to take 8 groups of 10 readings (multiple trigger arming). This will place a total of 80 readings in memory.

```
10 OUTPUT 722;"TARM HOLD"!SUSPEND READINGS
20 OUTPUT 722;"DCV 1"!DC VOLTAGE, 1 V RANGE
30 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
40 OUTPUT 722;"TRIG AUTO"!AUTO TRIGGER EVENT
50 OUTPUT 722;"NRDGS 10,AUTO"!10 READINGS/TRIGGER, AUTO SAMPLE EVENT
60 OUTPUT 722;"TARM SGL,8"!ARM TRIGGERING 8 TIMES
70 END
```

The stored readings can now be accessed by individual reading number (1 through 80) or by record/reading number (e.g. the 3rd reading in record 2 is also reading number 13). For example, the following program returns and displays reading number 50 (the 31st reading taken by the above program).

```
10 OUTPUT 722;"RMEM 50"!RECALL READING NUMBER 50
20 ENTER 722;A!ENTER READING
30 PRINT A!PRINT READING
40 END
```

The following program uses the first parameter and the count parameter to return and display the readings numbered 12 through 17.

```
10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(6)!DIMENSION ARRAY FOR 6 READINGS
30 OUTPUT 722;"RMEM 12,6"!RECALL 6 READINGS, STARTING WITH #12
40 ENTER 722;Rdgs(*)!ENTER READINGS
50 PRINT Rdgs(*)!PRINT READINGS
60 END
```

You can also use record numbers when recalling readings. The multimeter assigns the lowest record number (1) to the most recent record and the highest number to the oldest record. The following program returns the 3rd and 4th reading in record number 6 {in this case, readings numbered 53 and 54, respectively).

```
10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(2)!DIMENSION ARRAY FOR READINGS
30 OUTPUT 722;"RMEM 3,2,6"!RECALL 3rd & 4th READINGS FROM RECORD #6
40 ENTER 722;Rdgs(*)!ENTER READINGS
50 PRINT Rdgs(*)!PRINT READINGS
60 END
```

When executing RMEM from the front panel, after recalling a reading by reading number, you can use the up or down arrow keys to scroll through the other readings in memory. (The RMEM command is the only way to retrieve stored readings from the front panel.)

Using implied read

When the controller requests data from the multimeter and its output buffer is empty with reading memory enabled, a reading is removed from memory, placed in the output buffer, and transferred to the controller. This is the "implied read" method of recalling readings. Unlike the RMEM command, the implied read removes readings from memory. In the LIFO mode, the most recent reading is returned. In the FIFO mode, the oldest reading is returned. The following program makes 200 readings, places them in reading memory, and uses the implied read to transfer the readings to the controller.

```
10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(200) !DIMENSION ARRAY FOR 200 READINGS
30 OUTPUT 722;"PRESET NORM" !TARM AUTO, TRIG SYN, DCV AUTORANGE
40 OUTPUT 722;"NRDGS 200,AUTO" !200 READINGS/TRIGGER, AUTO SAMPLE EVENT
50 OUTPUT 722;"MEM FIFO" !ENABLE READING MEMORY, FIFO MODE
60 OUTPUT 722;"TRIG SGL" !TRIGGER READINGS
70 PAUSE !PAUSE PROGRAM, PRESS CONTINUE TO RESUME
80 ENTER 722;Rdgs(*) !ENTER READINGS
90 PRINT Rdgs(*) !PRINT READINGS
100 END
```


Sending Readings Across the Bus

This section describes the output formats for readings and how to transfer readings from the multimeter to the controller.

Output formats

The multimeter sends readings to the GPIB output buffer whenever readings are being taken and reading memory is not enabled (MEM OFF command). (In the power-on, RESET, or any of the PRESET states, reading memory is not enabled.) The five output formats and the number of bytes per reading are:

ASCII-- 15bytes per reading
SINT -- 2per reading
DINT -- 4bytes per reading
SREAL-- 4bytes per reading
DREAL-- 8bytes per reading

- ASCII This is the most commonly used output format because it has no scale factor and requires no special handling by the controller to convert the data. Since ASCII uses the greatest number of bytes per reading, use this format when measurement speed is not critical.

NOTE

When using the ASCII format, 2 additional bytes are required for the carriage-return, line-feed (**cr, lf**) end of line sequence. The **cr, lf** is used only for the ASCII format and normally follows each reading output in **ASCII** format. However, when using the ASCII output format and multiple readings are recalled from reading memory using the RMEM command, the multimeter places a comma between readings (comma = 1 byte). In this case, the **cr, lf** occurs only once, following the last reading in the group being recalled. Commas are not used when readings are output directly to the bus (reading memory disabled), when readings are recalled using “implied read”, or when using any other output format.

- Single Integer (SINT) or Double Integer (DINT) Use the SINT format when making low-resolution measurements (3.5 or 4.5 digits) at the highest possible rate on a fixed range (autorange disabled). (Since the SINT format is only 2 bytes per reading, readings can be transferred across GPIB faster using SINT than any other format.) Use the DINT format when making high-resolution

measurements (5.5 digits or greater) at the highest possible speed on a fixed range.

NOTE

When using the SINT or DINT memory/output format, the multimeter applies a scale factor to the readings. The scale factor is based on the multimeter's measurement function, range, A/D converter setup, and enabled math operations. You should not use the SINT or DINT format for frequency or period measurements; when a real-time or post-process math operation is enabled (except STAT or PFAIL); or when autorange is enabled.

- Single Real (SREAL) or Double Real (DREAL) Unlike the SINT and DINT formats, readings output in SREAL or DREAL format are not scaled and can be used with any measurement function/multimeter configuration. (Since there is no scale factor, the SREAL and DREAL formats are ideal when autoranging and/or a math function is enabled.) The DREAL format has the added advantage that no conversion is necessary by the controller. Use the SREAL, format for measurements with ≤ 6.5 digits of resolution. Use the DREAL format for measurements with > 6.5 digits of resolution.

The OFORMAT command specifies the output format for readings (the power on and default format is ASCII). For example, to select the double integer format, send:

OUTPUT 722; "OFORMAT DINT"

Overload indication

The multimeter indicates an overload condition (input greater than the present range can measure) by outputting the largest number possible for the particular output format as follows.

SINT format: +32767 or -32768 (unscaled)

DINT format: +2.147483647E+9 or -2.147483648E+9 (unscaled)

ASCII, SREAL, DREAL: +/-1.0E+38

Output termination

Each reading output to the GPIB in ASCII format is normally followed by *cr lf* (carriage return, line feed). The *cr lf* indicates the end of transmission to most controllers. Readings output in any other format do not have the *cr lf* end of line sequence. With any output format, you can enable the GPIB EOI (End Or Identify) function to mark the end of transmission. Refer to the END command in [Chapter 6](#) for more information.

Using the SINT or DINT output format

The ISCALE? command returns the scale factor (in ASCII format) for readings output in the SINT or DINT format. (After the controller retrieves the scale factor, the output format returns to the specified SINT or DINT format.) You can retrieve the scale factor after the multimeter is configured but before readings are triggered, or after all readings are completed and transferred to the controller. (If a reading is in the output buffer when the ISCALE? command is executed, the reading will be overwritten by the scale factor.)

SINT example

The following program outputs 10 readings in SINT format, retrieves the scale factor and multiplies the scale factor times each reading. The readings are transferred to the controller using the TRANSFER statement (this command is specific to Hewlett-Packard 200/300 controllers using BASIC language). The TRANSFER statement is the fastest way to transfer readings across the GPIB, especially when used with the direct memory access (DMA) GPIB interface. You should use the TRANSFER statement whenever measurement/transfer speed is important.

```
10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20INTEGER Num_readings!DECLARE VARIABLE
30INTEGER Int_rdg (1: 10) BUFFER!CREATE INTEGER BUFFER ARRAY
40REAL Rdg(1:10)!CREATE REAL ARRAY
50Num_readings=10!NUMBER OF READINGS = 10
60ASSIGN @Dvm TO 722!ASSIGN MULTIMETER ADDRESS
70 ASSIGN Int_rdg TO BUFFER Int_rdg(*)!ASSIGN BUFFER I/O PATH NAME
80 OUTPUT @Dvm;"PRESET NORM;OFORMAT SINT;NPLC 0;NRDGS ";Num_readings
85 !TARM AUTO, TRIG SYN, SINT OUTPUT FORMAT, MIN. INTEGRATION TIME
90TRANSFER @Dvm TO @Int_rdg;WAIT!SYN EVENT,TRANSFER READINGS INTO
91!INTEGER ARRAY; SINCE THE COMPUTER'S INTEGER FORMAT IS THE SAME AS
```

```

95!SINT,NO DATA CONVERSION IS NECESSARY HERE (INTEGER ARRAY REQUIRED)
100OUTPUT @Dvm;"I SCALE?"!QUERY SCALE FACTOR FOR SINT FORMAT
110ENTER @Dvm;S!ENTER SCALE FACTOR
120FOR I=1 TO Num_readings
130Rdgs(I)=Int_rdgs(I)!CONVERT EACH INTEGER READING TO REAL
135 !FORMAT (NECESSARY TO PREVENT POSSIBLE INTEGER OVERFLOW ON NEXT
LINE)
140R=ABS(Rdgs(I))!USE ABSOLUTE VALUE TO CHECK FOR OVLD
150IF R>=32767 THEN PRINT "OVLD"!IF OVLD,PRINT OVERLOAD MESSAGE
160Rdgs(I)=Rdgs(I)*S!MULTIPLY READING TIMES SCALE FACTOR
170Rdgs(I)=DROUND(Rdgs(I),4)!ROUND TO 4 DIGITS
180NEXT I
190END

```

DINT example

The following program is similar to the preceding program except that it takes 50 readings and transfers them to the computer using the DINT format.

```

100OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20INTEGER Num_readings,L,J,K!DECLARE VARIABLES
30Num_readings= 50! NUMBER OF READINGS = 50
40ALLOCATE REAL Rdgs(1:Num_readings)!CREATE ARRAY FOR READINGS
50ASSIGN @Dvm TO 722!ASSIGN MULTIMETER ADDRESS
60ASSIGN @Buffer TO BUFFER[4*Num_readings]!ASSIGN BUFFER I/O PATH NAME
70OUTPUT @Dvm;"PRESET NORM;RANGE 10;FORMAT DINT;NRDGS";Num_readings
75TARM AUTO, TRIG SYN,DCV 10 V RANGE,DINT OUTPUT FORMAT,NRDGS 50,AUTO
80TRANSFER @Dvm TO @Buffer;WAIT!SYN EVENT, TRANSFER READINGS
90OUTPUT @Dvm;"1 SCALE?"!QUERY SCALE FOR DINT
100ENTER @Dvm;S!ENTER SCALE FACTOR
110FOR I=1 TO Num_readings
120ENTER @Buffer USING "#,W,W";J,K!ENTER ONE 16-BIT 2's COMPLEMENT
121!WORD INTO EACH VARIABLE J AND K(# = STATEMENT TERMINATION NOT
125!REQUIRED; W = ENTER DATA AS 16-BIT 2'S COMPLEMENT INTEGER)
130Rdgs(I)=(J*65536.+K+65536.*(K<0))!CONVERT TO REAL NUMBER
140R=ABS(Rdgs(I))!USE ABSOLUTE VALUE TO CHECK FOR OVLD
150IF R>2147483647 THEN PRINT "OVLD"!IF OVERLOAD OCCURRED, PRINT
MESSAGE
160Rdgs(I)=Rdgs(I)*S!APPLY SCALE FACTOR
170Rdgs(I)=DROUND(Rdgs(I),8)!ROUND CONVERTED READING
180PRINT Rdgs(I)!PRINT READINGS
190NEXT I
200END

```

Using the SREAL output format

The following program shows how to convert 10 readings output in the SREAL format.

```

100OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20INTEGER Num_readings!DECLARE VARIABLE
30Num_readings=10!NUMBER OF READINGS = 10
40ALLOCATE REAL Rdgs(1:Num_readings)!CREATE ARRAY FOR READINGS
50ASSIGN @Dvm TO 722!ASSIGN MULTIMETER ADDRESS
60ASSIGN @Buffer TO BUFFER [4*Num_readings] !ASSIGN BUFFER I/O PATH
NAME
70OUTPUT @Dvm;"PRESET NORM;OFORMAT SREAL;NRDGS";Num_readings
75!TRIG SYN, SREAL OUTPUT FORMAT, 1 PLC, DCV AUTORANGE, 10 READINGS
80TRANSFER @Dvm TO @Buffer;WAIT!SYN EVENT; TRANSFER READINGS
90FOR I=1 TO Num_readings
100ENTER @Buffer USING "#,B";A,B,C,D!ENTER ONE 8-BIT BYTE INTO
101!EACH VARIABLE, (# =STATEMENT TERMINATION NOT REQUIRED, B = ENTER ONE
105!8-BIT BYTE AND INTERPRET AS AN INTEGER BETWEEN 0 AND 255)
110S=1!CONVERT READING FROM SREAL
120IF A>127 THEN S=-1!CONVERT READING FROM SREAL
130IF A>127 THEN A=A-128!CONVERT READING FROM SREAL
140A=A*2- 127!CONVERT READING FROM SREAL
150IF B>127 THEN A=A+1!CONVERT READING FROM SREAL
160IF B<=127 THEN B=B+128!CONVERT READING FROM SREAL
170Rdgs(I)=S*(B*65536.+C*256.+D)*2^(A-23)!CONVERT READING FROM SREAL
180Rdgs(I)=DROUND(Rdgs(I),7)!ROUND READING TO 7 DIGITS; YOU
181!MUST DO THIS WITH SREAL TO ENSURE ANY OVLD VALUES ARE ROUNDED TO
185!1.E+38 (WITHOUT ROUNDING, THE VALUE MAY BE SLIGHTLY LESS)
190IF ABS(Rdgs(I))=1.E+38 THEN!IF OVERLOAD OCCURRED:
200PRINT "Overload Occurred"!PRINT OVERLOAD MESSAGE
210ELSE!IF NO OVERLOAD OCCURRED:
220PRINT Rdgs(I)!PRINT READING
230END IF
240NEXT I
250END

```

Using the DREAL output format

The following program uses the DREAL output format. Notice that no conversion is necessary using this format since DREAL is the same format that the controller uses as its internal data format (8-bytes/word).

```

10OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20REAL Rdgs(1:10) BUFFER!CREATE BUFFER ARRAY
30ASSIGN @Dvm TO 722!ASSIGN MULTIMETER ADDRESS
40ASSIGN @Rdgs TO BUFFER Rdgs(*)!ASSIGN BUFFER I/O PATH NAME
50OUTPUT @Dvm;1'PRESET NORM;NPLC 10;OFORMAT DREAL;NRDGS 10"
55!TRIG SYN, 10 PLCs, DCV AUTORANGE, DREAL OUTPUT FORMAT, 10 RDGS/TRIG.
60TRANSFER @Dvm TO @Rdgs;WAIT!SYN EVENT, TRANSFER READINGS
70FOR I=1 TO 10
80IF ABS(Rdgs(I))=1.E+38 THEN!IF OVERLOAD OCCURRED:
90PRINT "OVERLOAD OCCURRED"!PRINT OVERLOAD MESSAGE
100ELSE!IF NO OVERLOAD:
110Rdgs(I)=DROUND(Rdgs(I),8)!ROUND READINGS
120PRINT Rdgs(I)!PRINT READINGS
130END IF
140NEXT I
150END

```

The preceding program used the TRANSFER statement to get readings from the multimeter. The following program uses the ENTER statement to transfer readings to the computer using the DREAL format. The ENTER statement is easier to use since no I/O path is necessary but is much slower than the TRANSFER statement. Also when using the ENTER statement, you must use the FORMAT OFF command to instruct the controller to use its internal data structure instead of ASCII.

```

10OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT
20Num_readings=20!NUMBER OF READINGS = 20
30ALLOCATE REAL Rdgs(1:Num_readings)!CREATE ARRAY FOR READINGS
40ASSIGN @Dvm TO 722!ASSIGN MULTIMETER ADDRESS
50OUTPUT @Dvm;"PRESET NORM;OFORMAT DREAL;NPLC 10;NRDGS";Num_readings
55!TRIG SYN, DCV AUTORANGE, DREAL OUTPUT FORMAT, 10 PLC, 20 READINGS/
TRIG
60ASSIGN @Dvm;FORMAT OFF!USE 8-BYTE/WORD DATA STRUCTURE
70FOR I=1 TO Num_readings
80ENTER @Dvm;Rdgs(I)!ENTER EACH READING
90IF ABS(Rdgs(I))=1.E+38 THEN!IF OVERLOAD OCCURRED:
100PRINT "OVERLOAD OCCURRED"!PRINT OVERLOAD MESSAGE
110ELSE!IF NO OVERLOAD OCCURRED

```

```
120Rdgs(I)=DROUND(Rdgs(1),8)!ROUND READINGS TO 8 DIGITS
130PRINT Rdgs(I)!PRINT READINGS
140END IF
150NEXT I
160END
```

Increasing the Reading Rate

This section discusses the multimeter's high-speed mode and the factors that affect the reading rate. It contains program examples that show how to increase the reading rate, how to transfer readings at high-speed directly to the controller, how to perform high-speed transfers from reading memory to the controller, and how to determine the reading rate.

High-speed mode

For DC voltage, DC current, 2- or 4-wire ohms, and direct- or sub-sampled measurements,^[1] the multimeter enters the high-speed mode when readings are initiated, the integration time is less than 10 PLCs, and the following commands have been executed:

ARANGE OFF

DISP OFF

MATH OFF

MFORMAT SINT or DINT (only required when reading memory is enabled)

OFORMAT SINT or DINT (only required when reading memory is not enabled)

While readings are being taken in the high-speed mode, the multimeter becomes completely dedicated to the measurement process. This means that it will not process any commands until the specified readings are completed. When readings are being sent directly to the output buffer in the high-speed mode, the multimeter waits until each reading is removed from the output buffer before placing the next reading in the output buffer. This ensures that readings will not be lost because of bus/controller speed limitations. (When not in the high-speed mode, the multimeter will write-over any reading in the output buffer when a new reading is available.)

If reading memory is enabled in the FIFO mode and reading memory becomes full in the high-speed mode, the trigger arm event becomes HOLD which stops readings and removes the multimeter from the high-speed mode. After removing some or all of the readings from memory, you can resume measurements by changing the trigger arm event (TARM command). In the LIFO mode, when reading memory becomes full, the oldest readings are replaced with the newest readings regardless of whether in high-speed mode or not.

[1] Refer to [Chapter 5](#) for more information on direct- and sub-sampled measurements.

NOTE

In the high-speed mode, the input buffer is temporarily disabled while readings are being made. Also, if END ALWAYS was specified (specifies the GPIB EOI mode), the EOI mode changes to END ON while the readings are being made. Following completion of the readings, the input buffer mode and the EOI mode return to that previously specified.

In the high-speed mode, the multimeter will respond only to the GPIB CLEAR command (Device Clear). If for some reason you must remove the multimeter from the high-speed mode, send the following:

CLEAR 722

The CLEAR command suspends measurements which removes the multimeter from the high-speed mode. Refer to [Appendix B](#) for more information on the GPIB CLEAR command.

Configuring for fast readings

The PRESET FAST command executes a series of commands that configure for fast readings. In addition, the reading rate is affected by the integration time and/or resolution; triggering setup: delay time; AC bandwidth (for AC measurements only); and, for resistance measurements only, the offset compensation mode.

NOTE

In addition to the commands discussed in this section, the DEFEAT command can be used to speed throughput by disabling the multimeter's input protection algorithm and some syntax and error checking algorithms. With these algorithms disabled, the multimeter can change to a new measurement configuration faster than it can with them disabled. Refer to the DEFEAT command in [Chapter 6](#) for details and a CAUTION statement concerning its use.

PRESET FAST command

The PRESET FAST command disables many functions that slow the reading rate and configures the multimeter for fast reading transfer to memory and to the GPIB. Table 4-3 shows the speed-related commands executed by PRESET FAST and the reason for executing each.

Table 4-3 Commands executed by PRESET FAST

Command	Reason
DCV 10	Selects DC voltage measurements on the 10 V range, which disables autorange. The autorange function samples the input before each reading, taking more time per reading than readings made on a fixed range. The disadvantage of a fixed range is lower resolution for signals that are less than 10% of full scale and the possibility of an overload condition for readings greater than full scale.
AZERO OFF	With autozero enabled, a zero measurement is made following each reading (for DC measurements only), which increases the time per reading.
DISP OFF	The time required for the multimeter to update its display slows the reading rate.
MATH OFF	Any enabled real-time math operation(s) slow the reading rate. If you must perform math operations on readings, use the post-process math (MMATH command). Refer to Math Operations later in this chapter for more information.
MFORMAT DINT	Readings come from the A/D converter in either SINT or DINT format (the format used depends on the specified measurement resolution; ^[a] in the configuration selected by PRESET FAST, the A/D converter uses DINT). The fastest way to transfer readings to reading memory is to have the memory format (MFORMAT) match the A/D converter's format so that no conversion is necessary. (Refer to Reading Formats earlier in this chapter for information on when to use SINT or DINT).
OFORMAT DINT	Readings come from the A/D converter in either SINT or DINT format (the format used depends on the specified measurement resolution; ^[a] in the configuration selected by PRESET FAST, the A/D converter uses DINT). The fastest way to transfer readings to the output buffer is to have the output format (OFORMAT) match the A/D converter's format so that no conversion is necessary. In addition, when the output format matches the reading memory format, no conversion is required to recall readings from memory. Remember to use the ISCALE? command to retrieve the scale factor when using the SINT or DINT output format. (Refer to Reading Formats earlier in the chapter for information on when to use SINT or DINT.)

[a] For direct-sampled digitizing, the format used depends on the amplitude of the input signal. Refer to [Chapter 5](#) for details.

Integration time and resolution

DC, ohms, and analog AC measurements: The specified integration time and/or resolution have a major effect on the reading rate for DC voltage; DC current: 2-wire or 4-wire ohms; AC or AC+DC current: and AC or AC+DC voltage (using the SETACV ANA method only). The longer the integration time (or the greater the resolution), the slower the reading rate. The specifications in [Appendix A](#) show selected reading rates for each of these measurements based on integration time.

Sampled AC voltage measurements: For AC or AC+DC voltage measurements using SETACV SYNC or SETACV RNDM, the integration time is fixed and cannot be changed. For these measurements, the specified resolution has a major effect on the reading rate. The specifications in [Appendix A](#) show selected reading rates for sampled AC measurements based on the specified resolution.

Frequency or period measurements: The integration time does not affect frequency or period measurements. For these measurements, the specified resolution (which also selects gate time) has a major effect on the reading rate. The specifications in [Appendix A](#) show reading rates for frequency and period measurements based on the specified resolution.

Triggering setup

To ensure the fastest triggering configuration, set the trigger arm, trigger, and sample events to AUTO. You can also use the TIMER sample event (or the SWEEP command). Assuming you do not generate the TRIGGER TOO FAST error, the reading rate is the reciprocal of the TIMER or SWEEP interval.

Delay time

Under normal operation, the multimeter automatically determines a delay time (default delay) based on the present measurement function, range, resolution, and for AC measurements, the AC bandwidth setting. This delay time is actually the settling time inserted before the first reading, which ensures accurate readings. The default delay has a large effect on the reading rate for analog AC measurements and a minimal effect on the reading rate for sampled AC voltage or DC measurements. For analog AC measurements, you can achieve a faster reading rate by specifying a shorter delay than the default value. However, the resulting settling time may not produce accurate measurements.

AC bandwidth

For the fastest AC measurements, specify the AC bandwidth (ACBAND command) to match the frequency content of the input signal. The specifications in [Appendix A](#) show the reading rates for AC measurements based on the frequency components of the input signal.

Offset compensation

For 2- and 4-wire ohms measurements with offset compensation enabled, an offset voltage measurement is made before each resistance reading. This requires more time than with offset compensation disabled (OCOMP OFF).

High-speed DCV example

The following program measures DC voltage at the fastest. possible rate (>100k readings per second). The readings are stored in reading memory.

```
10 OUTPUT 722;"PRESET FAST"!DCV, 10 V RANGE, TARM SYN, TRIG AUTO
20 OUTPUT 722;"APER 1.4E-6"!LONGEST INTEGRATION TIME POSSIBLE FOR
25 !>100K READINGS PER SECOND
30 OUTPUT 722;"MFORMAT SINT"!SINT MEMORY FORMAT
40 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY
50 OUTPUT 722;"NRDGS 10000,AUTO!10000 READINGS/TRIGGER, AUTO SAMPLE
EVENT
60 OUTPUT 722;"TARM SGL"!TRIGGER READINGS
70 END
```

High-speed OHM (or OHMF) example

The following program measures 2-wire ohms at the fastest possible rate (>100k readings per second). This program can be adapted to 4-wire ohms by using the OHMF command instead of the OHM command in line 50.

```
10 OUTPUT 722;"PRESET FAST"!DCV 10 V RANGE, TARM SYN, TRIG AUTO
20 OUTPUT 722;"APER 1.4E-6"!LONGEST INTEGRATION TIME POSSIBLE FOR
25 !>100K READINGS PER SECOND
30 OUTPUT 722;"MFORMAT SINT"!SINT MEMORY FORMAT
40 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY
50 OUTPUT 722;"OHM 100E3"!2-WIRE OHMS, 100 K( $\Omega$ ) RANGE
60 OUTPUT 722;"NRDGS 10000,AUTO"!10000 READINGS/TRIGGER, AUTO SAMPLE
EVENT
70 OUTPUT 722;"TARM SGL"!TRIGGER READINGS
80 END
```

High-speed DCI example

The following program measures DC current at the fastest possible rate.

```
10 OUTPUT 722;"PRESET FAST"!DCV, 10 V RANGE, TARM SYN, TRIG AUTO
20 OUTPUT 722;"APER 1.4E-6"!LONGEST INTEGRATION TIME POSSIBLE FOR
25 !MAXIMUM READING RATE
30 OUTPUT 722;"MFORMAT SINT"!SINT MEMORY FORMAT
40 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY
50 OUTPUT 722;"DCI 100E-3"!DC CURRENT, 100 mA RANGE
60 OUTPUT 722;"NRDGS 5000 AUTO"!5000 READINGS/TRIGGER, AUTO SAMPLE
EVENT
70 OUTPUT 722;"TARM SGL"!TRIGGER READINGS
80 END
```

Fast synchronous ACV/ACDCV example

The following program measures AC voltage using the synchronous method at the fastest possible rate (approximately 10 readings per second). This program can be adapted to AC+DC voltage by using the ACDCV command instead of the ACV command in line 50.

```
10 OUTPUT 722;"PRESET FAST"!TARM SYN, TRIG AUTO
20 OUTPUT 722;"MFORMAT SINT"!SINT MEMORY FORMAT
30 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY
40 OUTPUT 722;"SETACV SYNC"!SYNCHRONOUS AC MEASUREMENT METHOD
50 OUTPUT 722;"ACV 10,2"!AC VOLTS, 10 V RANGE, 2% RESOLUTION
60 OUTPUT 722;"ACBAND 5E3,8E3"!SIGNAL BETWEEN 5 kHz AND 8 kHz
70 OUTPUT 722;"NRDGS 20, AUTO"!20 READINGS/TRIGGER, AUTO SAMPLE EVENT
80 OUTPUT 722;"TARM SGL"!TRIGGER READINGS
90 END
```

Fast random ACV/ACDCV example

The following program measures AC voltage using the random method at the fastest possible rate (approximately 45 readings per second). This program can be adapted to AC+DC voltage by using the ACDCV command instead of the ACV command in line 50.

```
10 OUTPUT 722;"PRESET FAST"!TARM SYN, TRIG AUTO
20 OUTPUT 722;"MFORMAT SINT"!SINT MEMORY FORMAT
30 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY
40 OUTPUT 722;"SETACV RNDM"!RANDOM AC MEASUREMENT METHOD
50 OUTPUT 722;"ACV 10 6"!AC VOLTS, 10 V RANGE, 6% RESOLUTION
60 OUTPUT 722;"ACBAND 10E3,20E3"!SIGNAL BETWEEN 10 kHz AND 20 kHz
```

```

70 OUTPUT 722;"NRDGS 100, AUTO"!100 READINGS/TRIGGER, AUTO SAMPLE EVENT
80 OUTPUT 722;"TARM SGL"!TRIGGER READINGS
90 END

```

Fast analog ACV/ ACDCV example

The following program measures AC voltage using the analog method at a fast rate. This program uses the default delay time. You can achieve faster reading rates by specifying a shorter delay time; the resulting settling time, however, may not produce accurate measurements. You can also achieve unspecified faster reading rates by specifying less integration time in line 60. This program can be adapted to AC+DC voltage by using the ACDCV command instead of the ACV command in line 50.

```

10 OUTPUT 722;"PRESET FAST"!TARM SYN, TRIG AUTO
20 OUTPUT 722;"MFORMAT SINT"!SINT MEMORY FORMAT
30 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
40 OUTPUT 722;"SETACV ANA"!ANALOG AC MEASUREMENT METHOD
50 OUTPUT 722;"ACV 10"!AC VOLTS, 10 V RANGE
60 OUTPUT 722;"NPLC 0.1"!0.1 PLC INTEGRATION TIME
70 OUTPUT 722;"ACBAND 10E3,20E3"!SIGNAL BETWEEN 10 kHz AND 20 kHz
80 OUTPUT 722;"NRDGS 100, AUTO"!100 READINGS/TRIGGER, AUTO SAMPLE EVENT
90 OUTPUT 722;"TARM SGL"!TRIGGER READINGS
100 END

```

Fast ACI/ ACDCI example

The following program measures AC current at a fast rate. This program uses the default delay time. You can achieve faster reading rates by specifying a shorter delay time; the resulting settling time, however, may not produce accurate measurements. You can also achieve unspecified faster reading rates by specifying less integration time in line 50. This program can be adapted to AC+DC current by using the ACDCI command instead of the ACI command in line 40.

```

10 OUTPUT 722;"PRESET FAST"!TARM SYN, TRIG AUTO
20 OUTPUT 722;"MFORMAT SINT"!SINT MEMORY FORMAT
30 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
40 OUTPUT 722;"ACI 100E-3"!AC CURRENT, 100 mV RANGE
50 OUTPUT 722;"NPLC 0.1"!0.1 PLC INTEGRATION TIME
60 OUTPUT 722;"ACBAND 10E3,20E3"!SIGNAL BETWEEN 10 kHz AND 20 kHz
70 OUTPUT 722;"NRDGS 100,AUTO"!100 READINGS/TRIGGER, AUTO SAMPLE EVENT
80 OUTPUT 722;"TARM SGL"!TRIGGER READINGS
90 END

```

Fast FREQ (or PER) example

The following program measures frequency at a fast rate. This program can be adapted to measure period by using the PER command instead of the FREQ command in line 40.

```
10 OUTPUT 722;"PRESET FAST"!TARM SYN, TRIG AUTO
20 OUTPUT 722;"MFORMAT SREAL"!SINGLE REAL MEMORY FORMAT
30 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
40 OUTPUT 722;"FREQ 10, .1"!FREQUENCY, 10 V RANGE, 100  $\mu$ s GATE TIME
50 OUTPUT 722;"ACBAND 10E3,20E3"!SIGNAL BETWEEN 10 kHz AND 20 kHz
60 OUTPUT 722;"NRDGS 100, AUTO"!100 READINGS/TRIGGER, AUTO SAMPLE EVENT
70 OUTPUT 722;"TARM SGL"!TRIGGER READINGS
80 END
```

High-speed transfer across GPIB

Configuring the output format (OFORMAT command) to match the format used by the A/D converter (either SINT or DINT) ensures the fastest transfer of readings to the controller. This is because no format conversion is required in the multimeter. For high-speed, low-resolution readings (3.5 or 4.5 digits) made on a fixed range, use the SINT output format. (Because the SINT format uses only 2 bytes per reading, multiple readings can be transferred across the bus faster using the SINT output format than any other format.) For the fastest transfer of high resolution readings (5.5 digits or greater) made on a fixed range, use the DINT output format.

The multimeter is capable of taking readings and outputting them to the controller at >100k readings per second. Using the SINT output format at this reading rate, the GPIB and controller must be able to transfer data at >200k bytes per second. For Hewlett-Packard Series 200/300 Computers, this requires a direct memory access (DMA) card. In addition, devices that slow the operation of the GPIB bus and any unnecessary lengths of GPIB cable must be removed to achieve maximum transfer rate.

The following program transfers readings directly to the controller at the fastest possible rate. This program configures the multimeter to take readings at its maximum rate of >100k readings per second. Readings are output using the SINT format. If the bus/controller cannot transfer readings at >200k bytes per second, the reading rate will be slower. This is because, in the high-speed mode, the multimeter waits until each reading is removed from its output buffer before placing the next reading in the output buffer. In the following program, the SYN

trigger arm event is used to trigger the readings (TRIG SYN could also be used). The SYN event is very important for high-speed operation since it ensures the controller will be ready to accept the first reading output by the multimeter. The TRANSFER statement (line 120) satisfies the SYN event and is the fastest way to transfer readings across the GPIB, especially when used with the direct memory access (DMA) GPIB interface.

```

10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 INTEGER Num_readings!DECLARE VARIABLE
30 INTEGER Int_rdgs(1:30000) BUFFER!CREATE INTEGER ARRAY FOR BUFFER
40 REAL Rdgs(1:30000)!CREATE REAL ARRAY
50 Num_readings=30000!NUMBER OF READINGS = 30000
60 ASSIGN @Dvm TO 722!ASSIGN MULTIMETER ADDRESS
70 ASSIGN Int_rdgs TO BUFFER Int_rdgs(*)!ASSIGN BUFFER I/O PATH NAME
80 OUTPUT @Dvm; "PRESET FAST"!TARM SYN,TRIG AUTO, DCV 10 V
90 OUTPUT @Dvm;"APER 1.4E-6"!1.4  $\mu$ s INTEGRATION TIME
100 OUTPUT @Dvm; "OFORMAT SINT"!SINT OUTPUT FORMAT
110 OUTPUT @Dvm; "NRDGS"; Num_readings !30000 READINGS/TRIGGER, AUTO
115 !SAMPLE EVENT (DEFAULT VALUE)
120 TRANSFER @Dvm TO @Int rdgs;WAIT!SYN EVENT, TRANSFER READINGS INTO
121 !INTEGER ARRAY; SINCE THE COMPUTER'S INTEGER FORMAT IS THE SAME AS
125 !SINT,NO DATA CONVERSION IS NECESSARY HERE (INTEGER ARRAY REQUIRED)
130 OUTPUT @Dvm; "ISCALE?"!QUERY SCALE FACTOR FOR SINT FORMAT
140 ENTER @Dvm;S!ENTER SCALE FACTOR
150 FOR I=1 TO Num_readings
160 Rdgs(I)=Int_rdgs(I)!CONVERT EACH INTEGER READING TO REAL
165!FORMAT (NECESSARY TO PREVENT POSSIBLE INTEGER OVERFLOW ON NEXT LINE)
170 R=ABS(Rdgs(I))!USE ABSOLUTE VALUE TO CHECK FOR OVLD
180 IF R>=32767 THEN PRINT "OVLD"!IF OVLD, PRINT OVERLOAD MESSAGE
190 Rdgs(I)=Rdgs(I)*S!MULTIPLY READING TIMES SCALE FACTOR
200 Rdgs(I)=OROUND(Rdgs(I),4)!ROUND TO 4 DIGITS
210 NEXT I
220 END

```


High-speed transfer from memory

Configuring the reading memory format (MFORMAT command) to match the output format (OFORMAT command) helps to ensure command to match the fastest transfer of readings from reading memory to the controller. This is because no conversion is necessary when the readings are recalled from memory. For high-speed, low resolution readings (3.5 or 4.5 digits) made on a fixed range, use the SINT format. (Because the SINT format uses only 2 bytes per reading, multiple readings can be stored in memory and transferred across the bus faster using the SINT output format than any other format.) For the fastest transfer of high resolution readings (5.5 digits or greater) made on a fixed range, use the DINT format. Whenever autorange is enabled and transfer speed is critical, use the SREAL format (for readings of 6.5 digits or less) or the DREAL format (for readings of 7.5 or 8.5 digits). Disabling the display and any math operations will also ensure the fastest transfer from reading memory to the controller.

The following program is an example of transferring readings from reading memory to the controller at the fastest possible rate. The program stores 5000 readings in reading memory using the SINT format. The readings are removed from memory using the "implied read" and transferred to the controller (in the SINT format) using the TRANSFER statement (line 130). The controller then retrieves the scale factor, multiplies the scale factor times each reading, and stores the corrected readings in the *Rdgs* array.

```

10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 INTEGER Num_readings!DECLARE VARIABLE
30 INTEGER Int_rdgs(1:30000) BUFFER!CREATE INTEGER ARRAY FOR BUFFER
40 REAL Rdgs(1:30000)!CREATE REAL ARRAY
50 Num_readings=30000!NUMBER OF READINGS = 30000
60 ASSIGN @Dvm TO 722!ASSIGN MULTIMETER ADDRESS
70 ASSIGN Int_rdgs TO BUFFER Int_rdgs(*)!ASSIGN BUFFER I/O PATH NAME
80 OUTPUT @Dvm; "PRESET FAST"!TARM SYN,TRIG AUTO, DCV 10 V
90 OUTPUT @Dvm;"APER 1.4E-6"!1.4  $\mu$ s INTEGRATION TIME
100 OUTPUT @Dvm; "OFORMAT SINT"!SINT OUTPUT FORMAT
110 OUTPUT @Dvm; "NRDGS"; Num_readings !30000 READINGS/TRIGGER, AUTO
115 !SAMPLE EVENT (DEFAULT VALUE)
120 TRANSFER @Dvm TO @Int rdgs;WAIT!SYN EVENT, TRANSFER READINGS INTO
121 !INTEGER ARRAY; SINCE THE COMPUTER'S INTEGER FORMAT IS THE SAME AS
125 !SINT,NO DATA CONVERSION IS NECESSARY HERE (INTEGER ARRAY REQUIRED)
130 OUTPUT @Dvm; "ISCALE?"!QUERY SCALE FACTOR FOR SINT FORMAT
140 ENTER @Dvm;S!ENTER SCALE FACTOR
150 FOR I=1 TO Num_readings

```

```

160 Rdgs(I)=Int_rdgs(I)!CONVERT EACH INTEGER READING TO REAL
165!FORMAT (NECESSARY TO PREVENT POSSIBLE INTEGER OVERFLOW ON NEXT LINE)
170 R=ABS(Rdgs(I))!USE ABSOLUTE VALUE TO CHECK FOR OVLD
180 IF R>=32767 THEN PRINT "OVLD"!IF OVLD, PRINT OVERLOAD MESSAGE
190 Rdgs(I)=Rdgs(I)*S!MULTIPLY READING TIMES SCALE FACTOR
200 Rdgs(I)=OROUND(Rdgs(I),4)!ROUND TO 4 DIGITS
210 NEXT I
220 END

```

Determining the reading rate

When using the TIMER sample event or the SWEEP command, the reading rate is simply the reciprocal of the specified interval between readings (assuming the TRIGGER TOO FAST error does not occur). For example, if the TIMER interval is specified as 1E-4, the reading rate is $1/1\text{E-}4 = 10,000$ readings per second. When using another sample event, you can determine the reading rate by specifying a large number of readings per trigger specifying an output pulse after each reading (EXTOUT RCOMP command), and connecting an electronic frequency counter to the multimeter's Ext Out connector. The frequency displayed on the counter is the reading rate expressed in readings per second.

Another method uses the controller to time a number of readings initiated by the TARM SGL or TRIG SGL command. With the input buffer disabled (INBUF OFF), the SGL event holds the GPIB bus until the readings are complete. This means that the time required to execute the TARM SGL or TRIG SGL command is the total time of the measurement. For example, the following program stores readings in reading memory, times TARM SGL for 10000 readings, divides 10000 by the total time, and displays readings per second. The TIMEDATE command (lines 90 and 110) applies to Hewlett-Packard Series 200/300 computers using BASIC language. Refer to your computer operating manuals for more information on how to use your computer's timer.

```

10 REAL Num_readings!CREATE ARRAY
20 Num_readings=10000!NUMBER OF READINGS = 10000
30 ASSIGN @Dvm to 722!ASSIGN MULTIMETER ADDRESS
40 OUTPUT @Dvm;"PRESET FAST"!DCV 10 V RANGE, DINT MEM FORMAT, FAST
45 !READINGS, TARM SYN, TRIG AUTO
50 OUTPUT @Dvm;"NPLC 0"!MINIMUM INTEGRATION TIME (500 ns)
60 OUTPUT @Dvm;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
70 OUTPUT @Dvm;"MFORMAT SINT"!SINT MEMORY FORMAT
80 OUTPUT @Dvm;"NRDGS"; Num_readings ,"AUTO" ! 10000 READINGS/TRIGGER,
  AUTO

```

```

85 !SAMPLE EVENT
90 TO=TIMEDATE!START TIMER
100 OUTPUT @Dvm;"TARM SGL"!TRIGGER READINGS
110 T1=TIMEDATE!STOP TIMER
120 PRINT "Readings per second = ";Num_readings/(T1-T0)
125 !PRINT READINGS PER SECOND
130 END

```

If you are transferring multiple readings across the bus instead of using reading memory, you can use the SYN (synchronous) trigger arm or trigger event (which also holds the bus until all readings are complete and transferred) and time the controller's ENTER or TRANSFER statement. This is shown in the following program (the synchronous trigger arm event is selected by the PRESET FAST command in line 50).

```

10 REAL Num_readings!CREATE ARRAY
20 Num_readings=300000!NUMBER OF READINGS = 300000
30 ASSIGN @Dvm TO 722!ASSIGN MULTIMETER ADDRESS
40 ASSIGN @Buffer TO BUFFER [2*Num_readings] !ASSIGN BUFFER I/O PATH
NAME
50 OUTPUT @Dvm; "PRESET FAST"!DCV 10 V RANGE, DINT OUTPUT FORMAT,
55!TARM SYN, TRIG AUTO
60 OUTPUT @Dvm;"NPLC 0"!MINIMUM INTEGRATION TIME
70 OUTPUT @Dvm;"OFORMAT SINT"!SINT OUTPUT FORMAT
80 OUTPUT @Dvm; "NRDGS "; Num_readings, "AUTO"
85 !300000 READINGS/TRIGGER, AUTO SAMPLE EVENT
90 TO=TIMEDATE!BEGIN TIMING READINGS
100 TRANSFER @Dvm TO @Buffer;WAIT!SYN EVENT, TRANSFER READINGS
110 T1=TIMEDATE!STOP TIMING READINGS
120 PRINT "READINGS PER SECOND = 11;Num_readings/(T1/T0)
125!PRINT READINGS PER SECOND
130 END

```

NOTE

The time required to retrieve the scale factor (which is necessary to convert the readings output in SINT format) is not included in the above program.

The EXTOUT Signal

You can program the multimeter to output a TTL-compatible signal on its Ext Out connector when a specified A/D converter event occurs; when the multimeter generates a GPIB service request; or when the EXTOUT ONCE command is executed. This signal can be used to synchronize external equipment to the multimeter. The EXTOUT command's first parameter specifies the event that generates the signal and its second parameter specifies the signal's polarity: NEG = low-going, POS = high-going. The events that can generate a signal on the Ext Out connector are:

- Reading complete
- Burst of readings complete
- Input complete
- Aperture waveform
- Service Request
- Executing the EXTOUT ONCE command

Most of the above events apply to the multimeter's A/D converter. [Figure 4-5](#) shows the relationship of these events to the A/D converter activity.

NOTE

The apparent time intervals shown in [Figure 4-5](#) are for the illustration purposes only. They are not meant to indicate the actual intervals produced by the multimeter.

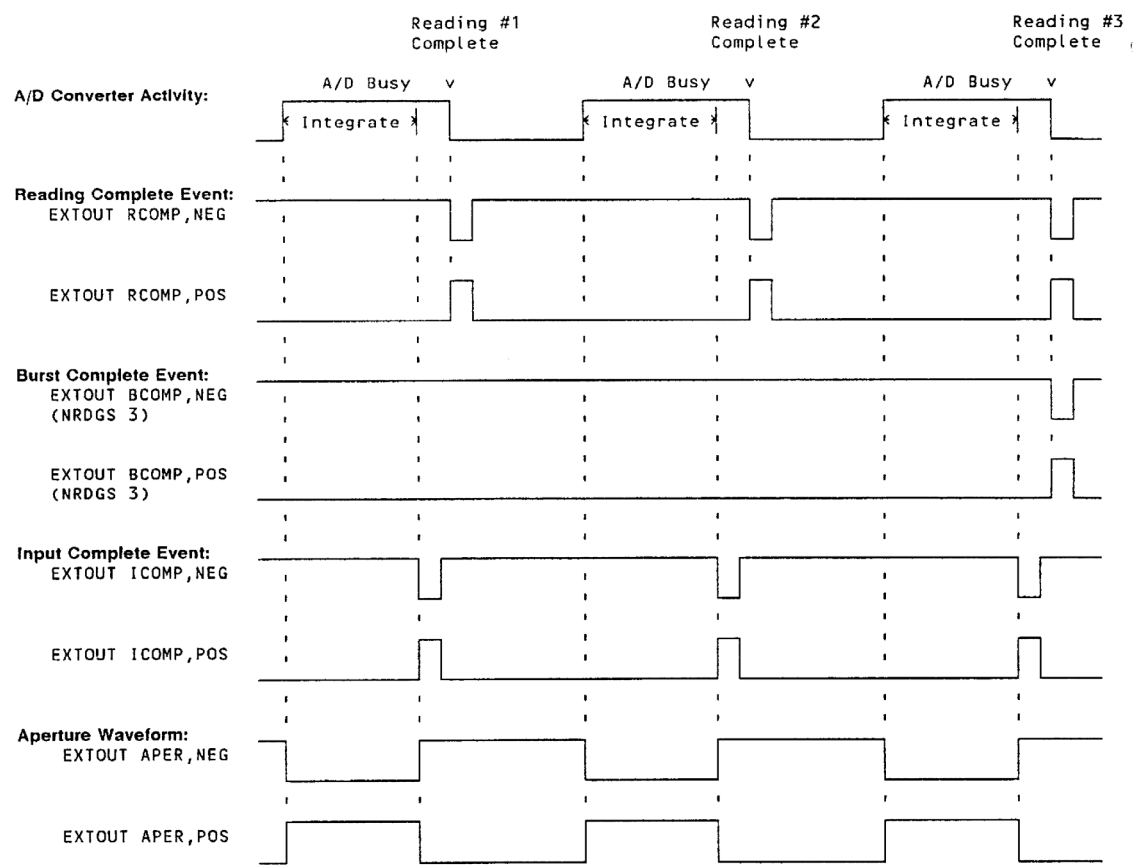


Figure 4-5 A/D Converter event relationships

Reading complete

When specified, the reading complete event (RCOMP event) produces a 1 μ s pulse following each reading for any measurement function. For sampled AC voltage measurements (SETACV SYNC or RNDM) a pulse is output after each computed reading, not after each sample in the measurement process. This event can be used to synchronize an external scanner to the multimeter when making one reading per scanner channel.

The following program uses the RCOMP event to synchronize the multimeter to a scanner (the example uses a 3235 Switch/Test Unit with a scanning module in slot 200). Measurement connections are shown in [Figure 4-6](#). The scanner is programmed to output a low-going pulse after each channel closure (line 60). This pulse is connected to the multimeter's Ext Trig connector and triggers each reading. After each reading, the multimeter's EXTOUT signal causes the scanner to advance to the next channel. The channel closure generates a signal which in turn triggers the next reading. This sequence repeats until all 6 channels have been scanned. Readings are stored in the multimeter's reading memory.

```

10 OUTPUT 722;"PRESET NORM"!DCV,NRDGS,1,AUTO, TARM AUTO, TRIG SYN
20 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
30 OUTPUT 722;"TRIG EXT"!TRIGGER EVENT = EXTERNAL
40 OUTPUT 722;"EXTOUT RCOMP,NEG" !READING COMPLETE EXTOUT, LOW-GOING
TTL
45!CONFIGURE EXTERNAL SCANNER
50 OUTPUT 709;"SADV EXTIN"!ADVANCE SCANNER ON MULTIMETER'S EXTOUT
SIGNAL
60 OUTPUT 709;"CHCLOSED EXT"!OUTPUT LOW-GOING PULSE AFTER EACH CLOSURE
70 OUTPUT 709;"SCAN 201- 206"!SCAN CHANNELS 01- 06 ON SCANNER IN SLOT
200
75 !AND ADVANCE TO CHANNEL 01, STARTING THE SCAN
80 END

```



```

85!AND ADVANCE TO CHANNEL 01, STARTING THE SCAN
90 END

```

Input complete

The input complete event (ICOMP event) is similar to the RCOMP event in that it produces a 1 μ s pulse for each reading. However, when the ICOMP event is specified, the pulse occurs when the A/D converter has finished integrating the input signal but before the reading is complete (see [Figure 4-5](#)). The ICOMP event can be used with an external scanner when making a single reading per scanner channel. This event is especially important when using a slower (relay type) scanner. Since the ICOMP event occurs before the reading is complete, it advances the scanner sooner than would the RCOMP event. The following program uses the ICOMP event to make one reading on each of 6 scanner channels. Notice that line 40 enables trigger buffering. This prevents the multimeter from generating the TRIGGER TOO FAST error should the scanner output a channel closed pulse before the present reading is complete. Connections for this example are shown in [Figure 4-6](#).

```

10 OUTPUT 722;"PRESET NORM"!DCV, NRDGS,1,AUTO, TARM AUTO, TRIG SYN
20 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
30 OUTPUT 722;"TRIG EXT"!TRIGGER EVENT = EXTERNAL
40 OUTPUT 722;"TBUFF ON"!ENABLE TRIGGER BUFFERING
50 OUTPUT 722 "EXTOUT ICOMP,NEG"!INPUT COMPLETE EXTOUT, LOW-GOING TTL
55!CONFIGURE EXTERNAL SCANNER
60 OUTPUT 709;"SADV EXTIN"!ADVANCE SCANNER ON MULTIMETER'S EXTOUT
  SIGNAL
70 OUTPUT 709;"CHCLOSED EXT"!OUTPUT LOW-GOING PULSE AFTER EACH CLOSURE
80 OUTPUT 709;"SCAN 201- 206"!SCAN CHANNELS 01 - 06 ON SCANNER IN SLOT
  200
85!AND ADVANCE TO CHANNEL 01 STARTING THE SCAN
90 END

```

Aperture waveform

When specified, the aperture waveform event (APER event) outputs a waveform indicating when the A/D converter is measuring the input signal. In addition to showing when a reading is being measured, the aperture waveform also shows any autozero and autorange measurements being made. This waveform can be used to synchronize external switching equipment to the multimeter. For example, to ensure an electrically quiet environment for high-accuracy measurements, it

may be necessary to suspend the operation of external switching equipment while the A/D converter is integrating each reading. This can be done by enabling the APER event and by programming the external switching to occur only when the aperture waveform indicates that the A/D converter is not integrating the input signal. To following program line enables the APER event with positive polarity (see [Figure 4-5](#)):

```
OUTPUT 722;"EXTOUT APER,POS"
```

Service request

When specified, the service request event (SRQ event) produces a 1 μ s pulse whenever the multimeter generates a GPIB service request. This event can be used to indicate to external equipment (especially equipment that cannot be connected to GPIB) that one or more specified events have occurred and have generated a service request (refer to [Using the Status Register](#) in [Chapter 3](#), for information on service requests).

NOTE

When a status event sets the SRQ bit in the register, that bit remains set until cleared (CSB command, for example). When specified, the EXTOUT SRQ pulse occurs whenever any status event occurs that has been enabled to assert SRQ (RQS command). The EXTOUT SRQ pulse does not necessarily occur whenever the SRQ bit is set; it occurs whenever an enabled status event occurs.

The following program uses the SRQ event to synchronize the multimeter to external equipment. The program downloads a subprogram to the multimeter. When the subprogram is called by the controller (line 120), it configures the multimeter for high-accuracy temperature measurements using a 10 k(Ω) thermistor. After the subprogram has been called and executed, bit 0 is set in the status register (program memory execution completed). This asserts a GPIB SRQ (enabled by line 30) and causes a pulse on the Ext Out connector (specified by line 40). This pulse signals external equipment that the multimeter is configured and ready to make measurements.

```
10 OUTPUT 722;"SUB EXTSRQ"! STORE SUBPROGRAM NAMED "EXTSRQ"
20 OUTPUT 722;"-PRESET NORM"! PRESET,TRIG SYN, TARM AUTO, NRDGS 1,AUTO
30 OUTPUT 722;"RQS 1"!ENABLE SUBPROGRAM EXECUTION COMPLETE BIT
40 OUTPUT 722;"EXTOUT SRQ,POS"!SRQ EXTOUT EVENT, HI-GOING PULSE
50 OUTPUT 722;"OHMF 10E3"!2-WIRE OHMS, 10 k $\Omega$  RANGE
60 OUTPUT 722;"NPLC 100"!100 PLCS INTEGRATION TIME
```

```

70 OUTPUT 722;"OCOMP ON"!ENABLE OFFSET COMPENSATION
80 OUTPUT 722;"TRIG EXT"!EXTERNAL TRIGGER EVENT
90 OUTPUT 722;"MATH CTHRM10K"!ENABLE 10 kΩ THERMISTOR MATH OPERATION
100 OUTPUT 722;"CSB"!CLEAR STATUS REGISTER
110 OUTPUT 722;"SUBEND"!END OF SUBPROGRAM
120 OUTPUT 722;"CALL EXTSRQ"!CALL SUBPROGRAM
130 END

```

EXTOUT ONCE

Executing the EXTOUT ONCE command produces a single 1 μ S pulse on the multimeter's Ext Out connector. After executing EXTOUT ONCE, the mode reverts to OFF (the EXTOUT signal is disabled). As shown in the following program. EXTOUT ONCE is useful in subprograms to indicate the completion of the subprogram, or a segment of the subprogram, to external equipment.

```

10 OUTPUT 722;"SUB EXTONCE"!STORE SUBPROGRAM NAMED "EXTONCE"
20 OUTPUT 722;"EXTOUT ONCE"!SIGNAL EXTERNAL EQUIPMENT TO SWITCH
25!TO DC VOLTAGE SIGNAL
30 OUTPUT 722;"PRESET FAST!FAST READINGS, TARM SYN, TRIG AUTO"
40 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
50 OUTPUT 722;"NRDGS 20"!20 READINGS PER TRIGGER
60 OUTPUT 722;"TARM SGL"!TRIGGER 20 READINGS
70 OUTPUT 722;"EXTOUT ONCE"!SIGNAL EXTERNAL EQUIPMENT TO SWITCH TO
75!RESISTANCE MEASUREMENT
80 OUTPUT 722;"OCOMP ON"!ENABLE OFFSET COMPENSATION
90OUTPUT 722;"OHM 1E3"!2-WIRE OHMS, 1 kΩ RANGE
100 OUTPUT 722;"NRDGS 40"!40 READINGS PER TRIGGER
110 OUTPUT 722;"TARM SGL!TRIGGER 40 READINGS"
120 OUTPUT 722;"SUBEND"!END OF SUBPROGRAM
130 OUTPUT 722;"CALL EXTONCE"!CALL SUBPROGRAM
140END

```

Math Operations

Each math operation performs a specific mathematical operation on each reading and/or stores data on a series of readings. The multimeter can perform the null, scale, percent, dB, dBm, filter, RMS, or temperature-related math operations on readings. The statistics and pass/fail math operations do not alter readings but store information pertaining to readings. This section describes how to enable and disable math operations and discusses each math operation in detail.

Real-time vs. post-process

Math operations can be performed real-time or post-process. When a real-time math operation is enabled, the operation is performed on each reading immediately after the reading is taken. The result can then be stored in reading memory or output over the GPIB. When enabled, a post-process math operation (except STAT and PFAIL) is performed on each reading as it is removed or copied from reading memory to the display or the GPIB output buffer. (The readings in memory are not altered by any post-process math operation.) The STAT or PFAIL post-process math operations are performed using the readings in memory immediately after executing the MMATH command. For the statistics operation, results are stored in the statistics registers. For the pass/fail operation, an out of limit reading sets bit number 1 in the status register and displays either FAILED HIGH or FAILED LOW depending on whether the high or low limit was exceeded.

Enabling math operations

To enable a math operation, send the MATH command (for real-time) or the MMATH command (for post-process) followed by the operation parameter (DB, DBM, FILTER, NULL, PERC, PFAIL, RMS, SCALE, STAT, or one of the temperature-related parameters; refer to "Measuring Temperature, later in this section for a listing of the temperature-related parameters). After enabling a math operation, it remains enabled until you disable it, cycle power, execute RESET, or execute one of the PRESET commands. For example, to enable the NULL operation, send:

```
OUTPUT 722; "MATH NULL" !ENABLES REAL-TIME NULL OPERATION
```

or

```
OUTPUT 722; "MMATH NULL" !ENABLES POST-PROCESS NULL OPERATION
```

Up to two math operations can be enabled at the same time. The operations are performed on each reading in the order listed in the command. For example, to enable the NULL and SCALE operations, send:

```
OUTPUT 722;"MATH NULL, SCALE" !ENABLEs REAL-TIME NULL & SCALE
```

or

```
OUTPUT 722;"MMATH NULL, SCALE" !ENABLES POST-PROCESS NULL & SCALE
```

To disable all enabled math operations, send:

```
OUTPUT 722;"MATH OFF" !DISABLES ALL REAL-TIME MATH OPERATIONS
```

or

```
OUTPUT 722;"MMATH OFF" !DISABLES ALL POST-PROCESS MATH OPERATIONS
```

Later you can re-enable the operation(s) that were disabled by the MATH OFF or MMATH OFF command. To re-enable a single math operation (if two operations were previously enabled, this will enable only the first of those two operations), send:

```
OUTPUT 722;"MATH CONT" !RE-ENABLES ONE REAL-TIME MATH OPERATION
```

or

```
OUTPUT 722;"MMATH CONT" !RE-ENABLES ONE POST-PROCESS MATH OPERATION
```

To re-enable two previously enabled math operations send:

```
OUTPUT 722;"MATH CONT,CONT" !RE-ENABLES TWO REAL-TIME MATH OPERATIONS
```

or

```
OUTPUT 722;"MMATH CONT,CONT" !RE-ENABLES TWO POST-PROCESS MATH OPERATIONS
```

Math registers

Table 4-4 shows the registers used by the real-time or post-process math operations.

Table 4-4 Math registers

Register name	Register contents
DEGREE	Time constant for FILTER and RMS
LOWER	Smallest reading in STATS
MAX	Upper limit for PFAIL operation
MEAN	Average of readings in STATS
MIN	Lower limit for PFAIL
NSAMP	Number of samples in STATS
OFFSET	Subtrahend in NULL and SCALE operations
PERC	Percent value for PERC operation
REF	Reference value for DB operation
RES	Reference impedance for DBM operation
SCALE	Divisor in the SCALE operation
SDEV	Standard deviation in STATS
UPPER	Largest reading in STATS
PFAILNUM	The number of readings that passed PFAIL before a failure was encountered

You can write a value to any math register (except SDEV) using the SMATH command. For example, to place the value of 22 in the DEGREE register, send:

```
OUTPUT 722;"SMATH DEGREE,22"
```

You can read the value in any math register using the RMATH command. For example, the following program reads and prints the value in the RES register.

```
10 OUTPUT 722;"RMATH RES"
20 ENTER 722;A
30 PRINT A
40 END
```

NULL

The NULL operation subtracts a value from each reading (following the first reading). The equation is:

$$\text{Result} = \text{Reading} - \text{OFFSET}$$

Where:

OFFSET is the value stored in the OFFSET register (typically the first reading).

Reading is any reading following the first reading.

After you select the NULL operation, the first reading made (real-time) or the first reading taken from memory (post-process) is stored in the OFFSET register. The value of this reading is then subtracted from all subsequent readings. If you do not want the first reading to be the null value, you can write another value to the OFFSET register using the SMATH command. You must wait, however, until after the first reading is made (real-time) or recalled (post-process) before changing the value.

A typical application of the NULL operation is in making more accurate 2-wire ohms measurements. To do this, select 2-wire ohms (OHM command) 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 then subtracts the value in the OFFSET register from all subsequent readings until the math NULL operation is disabled. This method is not as accurate as 4-wire ohms because the resistance of the test leads connected together probably will not be the same as when they are connected to the unknown resistance. Also, the resistance of the test leads is checked only once for a series of measurements and the test lead resistance may change.

The following program performs the real-time NULL math operation on 20 readings. After executing the NULL command, the first reading is triggered by line 50. The value in the OFFSET register is then changed to 3.05. The 20 readings are triggered by line 90 and 3.05 is subtracted from each reading.

```
10OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(20)!DIMENSION ARRAY FOR 20 READINGS
30 OUTPUT 722;"PRESET NORM"!PRESET, NRDGS 1,AUTO, DCV 10
40 OUTPUT 722;"MATH NULL"!ENABLE REAL-TIME NULL MATH OPERATION
50 OUTPUT 722;"TRIG SGL"!TRIGGER 1 READING, STORED IN OFFSET
60 OUTPUT 722;"SMATH OFFSET,3.05"!WRITE 3.05 TO OFFSET REGISTER
70 OUTPUT 722;"NRDGS 20"!20 READINGS PER TRIGGER
```

```

80 OUTPUT 722;"TRIG SYN"!SYN TRIGGER EVENT
90 ENTER 722;Rdgs(*)!SYN EVENT, ENTER NULL CORRECTED READINGS
100 PRINT Rdgs(*)!PRINT NULL CORRECTED READINGS
110 END

```

The following program performs the post-process NULL operation on 20 readings. After executing the MMATH NULL command, 21 readings are taken and stored in reading memory in FIFO mode. Line 80 recalls the first reading taken which is stored in the OFFSET register. The value in the OFFSET register is then changed to 3.05. The remaining 20 readings in memory are recalled and the NULL operation is performed on each.

```

10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(20)!DIMENSION ARRAY FOR 20 READINGS\
30 OUTPUT 722;"PRESET NORM"!PRESET,NRDGS 1,AUTO, DCV 10
40 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
50 OUTPUT 722;"MMATH NULL"!ENABLE POST-PROCESS NULL OPERATION
60 OUTPUT 722;"NRDGS 21"!21 READINGS PER TRIGGER
70 OUTPUT 722;"TRIG SGL"!TRIGGER READINGS
80 ENTER 722;A!RECALL FIRST READING USING IMPLIED READ
90 OUTPUT 722;"SMATH OFFSET,3.05"!WRITE 3.05 TO OFFSET REGISTER
100 ENTER 722;Rdgs(*)!RECALL READINGS USING IMPLIED READ,
105!PERFORM NULL OPERATION ON EACH
110 PRINT Rdgs(*)!PRINT NULL MODIFIED READINGS
120 END

```

SCALE

The SCALE operation modifies each reading by subtracting an offset and dividing by a scale factor. The equation is:

$$\text{Result} = (\text{Reading} - \text{OFFSET}) / \text{SCALE}$$

Where:

Reading is any reading.

OFFSET is the value stored in the OFFSET register (default = 0: notice that the first reading is not stored in OFFSET as it was for the NULL operation).

SCALE is the value stored in the SCALE register (default = 1).

Notice that the default values do not change the reading (they subtract 0 and divide by 1). You can change the values in the OFFSET register or the SCALE register using the SMATH command.

The following program uses the real-time scale operation to divide each of 20 readings by 2. The default value of 0 is left in the OFFSET register so no subtraction is done before the readings are scaled.

```

10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(20)!DIMENSION ARRAY FOR 20 READINGS
30 OUTPUT 722;"PRESET NORM"!PRESET, NRDGS 1,AUTO, DCV 10, TRIG SYN
40 OUTPUT 722;"NRDGS 20"!20 READINGS PER TRIGGER
50 OUTPUT 722;"MATH SCALE"!ENABLE REAL-TIME SCALE OPERATION
60 OUTPUT 722;"SMATH SCALE 2"!WRITE 2 TO SCALE REGISTER
70 ENTER 722;Rdgs(*)!SYN EVENT, ENTER SCALED READINGS
80 PRINT Rdgs(*)!PRINT SCALED READINGS
90 END

```

The following program uses the post-process scale operation to subtract the value of 1 from each reading and then divide each reading by 2.

```

10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(20)!DIMENSION ARRAY FOR 20 READINGS
30 OUTPUT 722;"PRESET NORM"!PRESET, NRDGS 1,AUTO, DCV 10, TRIG SYN
40 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
50 OUTPUT 722;"NRDGS 20"!20 READINGS PER TRIGGER
60 OUTPUT 722;"MMATH SCALE"!ENABLE POST-PROCESS SCALE OPERATION
70 OUTPUT 722;"SMATH OFFSET 1"!WRITE 1 TO OFFSET REGISTER
80 OUTPUT 722;"SMATH SCALE 2"!WRITE 2 TO SCALE REGISTER
90 OUTPUT 722;"TRIG SGL"!TRIGGER READINGS
100 ENTER 722;Rdgs(*)!RECALL READINGS USING IMPLIED READ,
105!PERFORM SCALE OPERATION ON EACH
110 PRINT Rdgs(*)!PRINT MATH RESULTS
120 END

```

Percent

The PERC math operation determines the difference, in percent, between each reading and the value in the PERC register. The equation is:

$$\text{Result} = ((\text{Reading} - \text{PERC})/\text{PERC}) \cdot 100$$

Where:

Reading is any reading.

PERC is the value stored in the PERC register (power-on value = 1).

You can use the PERC math operation to determine the difference (in percent) between an ideal value and the measured value. For example, the following

program determines the percent error of a 10 VDC voltage measurement. Line 60 enters the ideal value (10) into the PERC register. Line 70 triggers the 20 readings. If a reading is exactly 10 VDC, the value returned is 0. If a reading is, for example, 10.1 VDC, the value returned is:

$$\text{Result} = ((10.1 - 10)/10) \cdot 100 = 0.01 \cdot 100 = 1$$

```

10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Perc(20)!DIMENSION ARRAY FOR 20 PERCENTAGES
30 OUTPUT 722;"PRESET NORM"!PRESET, NRDGS 1,AUTO, DCV 10, TRIG SYN
40 OUTPUT 722;"NRDGS 20"!20 READINGS PER TRIGGER
50 OUTPUT 722;"MATH PERC"!ENABLE REAL-TIME PERC OPERATION
60 OUTPUT 722;"SMATH PERC 10"!WRITE 10 TO PERC REGISTER
70 ENTER 722;Perc(*)!SYN EVENT, ENTER PERCENT DIFFERENCE
80 PRINT Perc(*)!PRINT PERCENT DIFFERENCE
90 END

```

The following program is similar to the preceding program except that it uses the post-process PERC operation.

```

10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Perc(20)!DIMENSION ARRAY FOR 20 PERCENTAGES
30 OUTPUT 722;"PRESET NORM"!PRESET,NRDGS 1,AUTO, DCV 10, TRIG SYN
40 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
50 OUTPUT 722;"NRDGS 20"!20 READINGS PER TRIGGER
60 OUTPUT 722;"MMATH PERC"!ENABLE POST-PROCESS PERC OPERATION
70 OUTPUT 722;"SMATH PERC 10"!WRITE 10 TO PERC REGISTER
80 OUTPUT 722;"TRIG SGL"!TRIGGER READINGS
90 ENTER 722;Perc(*)!RECALL READINGS USING IMPLIED READ,
95 !PERFORM PERC OPERATION
100 PRINT Perc(*)!PRINT PERCENT DIFFERENCE
110 END

```

DB

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

$$\text{Result} = 20 \cdot \log_{10}(\text{Reading}/\text{REF})$$

Where:

Reading is any reading.

REF is the value in the REF register (default = 1).

You can change the value in the REF register using the SMATH command.

The following program uses the real-time DB operation to determine an amplifier's voltage gain. Line 40 stores the amplifier's input voltage (0.1 V) in the REF register. The amplifier's output voltage is measured and the gain of the amplifier is computed.

```

10 OUTPUT 722;"PRESET NORM"!PRESET,NRDGS 1,AUTO, DCV 10, TRIG SYN
20 OUTPUT 722;"ACV"!AC VOLTAGE MEASUREMENTS, AUTORANGE
30 OUTPUT 722;"SETACV ANA"!ANALOG ACV METHOD
40 OUTPUT 722;"SMATH REF 0.1"!WRITE 0.1 TO REF REGISTER
50 OUTPUT 722;"MATH DB"!ENABLE REAL-TIME DB OPERATION
60 ENTER 722;A!SYN EVENT, ENTER DB
70 PRINT A!PRINT DB
80 END

```

For example, if the input voltage is 0.1 V and the output voltage is 10 V, the gain is:

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

The following program is similar to the preceding program except that it uses the post-process DB operation.

```

10 OUTPUT 722;"PRESET NORM"!PRESET,NRDGS 1,AUTO, DCV 10, TRIG SYN
20 OUTPUT 722;"ACV"!AC VOLTAGE MEASUREMENTS, AUTORANGE
30 OUTPUT 722;"SETACV ANA"!ANALOG ACV METHOD
40 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
50 OUTPUT 722;"SMATH REF 0.1"!WRITE 0.1 TO REF REGISTER
60 OUTPUT 722;"MMATH DB"!ENABLE POST-PROCESS DB OPERATION
70 OUTPUT 722;"TRIG SGL"!TRIGGER READING
80 ENTER 722;A!RECALL READING USING IMPLIED READ,
85!PERFORM DB OPERATION
90 PRINT A!PRINT DB RESULT
100 END

```

DBM

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

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

Where:

Reading is any voltage reading.

RES is the resistance value in the RES register (default = 50)

You can change the value in the RES register using the SMATH command.

The following program uses the real-time DBM operation to determine the input power to a loudspeaker. Line 40 stores the speaker's impedance in the RES register (for this example, 8 Ω). The input voltage to the speaker is then measured and the DBM operation is performed.

```
10 OUTPUT 722;"PRESET NORM"!PRESET, NRDGS 1,AUTO, DCV 10, TRIG SYN
20 OUTPUT 722;"ACV"!AC VOLTAGE MEASUREMENTS, AUTORANGE
30 OUTPUT 722;"SETACV ANA"!ANALOG ACV METHOD
40 OUTPUT 722;"SMATH RES 8"!WRITE 8 TO RES REGISTER
50 OUTPUT 722;"MATH DBM"!ENABLE REAL-TIME DBM OPERATION
60 ENTER 722;A!SYN EVENT, ENTER DBM
70 PRINT A!PRINT DBM
80 END
```

For example, if the input voltage is 10 V, the power is:

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

The following program is similar to the preceding program except that it uses the post-process DBM operation.

```
10 OUTPUT 722;"PRESET NORM"!PRESET, NRDGS 1,AUTO, DCV 10, TRIG SYN
20 OUTPUT 722;"ACV"!AC VOLTAGE MEASUREMENTS, AUTORANGE
30 OUTPUT 722;"SETACV ANA"!ANALOG ACV METHOD
40 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
50 OUTPUT 722;"SMATH RES 8"!WRITE 8 TO RES REGISTER
60 OUTPUT 722;"MMATH DBM"!ENABLE POST-PROCESS DBM OPERATION
70 OUTPUT 722;"TRIG SGL"!TRIGGER READING
80 ENTER 722;A!RECALL READING USING IMPLIED READ,
85!PERFORM DBM OPERATION
90 PRINT A!PRINT DBM RESULT
100 END
```

Statistics

The STAT math operation performs five calculations on a group of readings and stores the results in five math registers. The calculations are: standard deviation, mean, number of samples, largest reading, and smallest reading. [Table 4-5](#) shows the STAT registers and their contents. You can read any of the STAT registers using the RMATH command.

Table 4-5 STAT registers

Register	Stored result
SDEV	Standard deviation
MEAN	Average of the readings
NSAMP	Number of readings in this group of measurements
UPPER	Largest reading in this group of measurements
LOWER	Smallest reading in this group of measurements

The following program uses the real-time STAT operation to perform five running calculations on 20 DC voltage readings. After the readings are taken and transferred to the controller, the standard deviation is read and returned.

```

10  OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20  DIM Rdgs(20)!DIMENSION ARRAY FOR 20 READINGS
30  OUTPUT 722;"PRESET NORM"!PRESET, NRDGS 1,AUTO, DCV 10, TRIG SYN
40  OUTPUT 722"NRDGS 20"!20 READINGS PER TRIGGER
50  OUTPUT 722;"MATH STAT"!ENABLE REAL-TIME STAT OPERATION
60  ENTER 722 Rdgs(*)!SYN EVENT, ENTER READINGS
70  OUTPUT 722;"RMATH SDEV"!READ STANDARD DEVIATION
80  ENTER 722;S!ENTER STANDARD DEVIATION
90  PRINT S!PRINT STANDARD DEVIATION
100 END

```

The following program performs the post-process STAT operation on 20 readings stored in memory. The post,-process STAT operation is a batch operation. That is the readings do not have to be recalled from memory in order to perform the STAT operation. Also notice that the readings must be stored before enabling the post-process STAT operation (if not, the MEMORY ERROR will occur).

```

10 OUTPUT 722;"PRESET NORM"!PRESET, NRDGS 1,AUTO, DCV 10, TRIG SYN
20 OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
30 OUTPUT 722;"NRDGS 20"!20 READINGS PER TRIGGER
40 OUTPUT 722;"TRIG SGL"!TRIGGER READINGS
50 OUTPUT 722;"MMATH STAT"!PERFORM POST-PROCESS STAT OPERATION
60 OUTPUT 722;"RMATH SDEV"!READ STANDARD DEVIATION
70 ENTER 722;S!ENTER STANDARD DEVIATION
80 PRINT S!PRINT STANDARD DEVIATION
90 END

```

Pass/Fail

The PFAIL math operation tests each reading against the limits set in the MAX and MIN registers. If a boundary is exceeded, the hi/low bit of the status register is set. Also, the number of readings that passed the PFAIL operation before a failure was encountered are logged in the PFAILNUM register. The default value is 0 for both the MAX and MIN registers. You can change the value in either register using the SMATH command.

The following program uses the real-time PFAIL operation to check 20 DCV readings against the high and low limits of 11 V and 9 V. After the readings have been triggered, the HI/LO LIMIT bit of the status register (bit 2) is checked. If one or more failures occurred, the PFAILNUM register is queried and its contents returned.

```

10 OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(20)!DIMENSION ARRAY FOR 20 READINGS
30 OUTPUT 722;"PRESET NORM"!PRESET, NRDGS 1,AUTO, DCV 10, TRIG SYN
40 OUTPUT 722;"MATH PFAIL"!ENABLE REAL-TIME PFAIL OPERATION
50 OUTPUT 722;"SMATH MIN 9"!LOWER LIMIT = 9(V)
60 OUTPUT 722;"SMATH MAX 11"!UPPER LIMIT = 11(V)
70 OUTPUT 722;"CSB"!CLEAR STATUS REGISTER
80 OUTPUT 722;"RQS 2"!ENABLE HI/LO STATUS REGISTER BIT
90 OUTPUT 722;"NRDGS 20"!20 READINGS/TRIGGER
100 ENTER 722;Rdgs(*)!SYN EVENT, ENTER READINGS
110 OUTPUT 722;"STB?"!QUERY SET BITS IN STATUS REGISTER
120 ENTER 722;A!ENTER QUERY RESPONSE
130 IF BINAND(A,2) THEN!IF BIT 2 IS SET:
140 PRINT "HI/LOW LIMIT TEST FAILED"!PRINT FAILURE MESSAGE
150 OUTPUT 722;"RMATH PFAILNUM"!QUERY PFAILNUM REGISTER
160 ENTER 722;B!ENTER QUERY RESPONSE
170 PRINT "NUMBER OF READINGS THAT PASSED BEFORE FAILURE WERE";B
175!PRINT PFAILNUM RESPONSE

```

```

180 ELSE!IF BIT 2 WAS NOT SET:
190 PRINT "HI/LOW LIMIT TEST PASSED"!PRINT TEST PASSED MESSAGE
200 END IF
210 END

```

The following program is similar to the preceding program except that it uses the post-process PFAIL operation on 20 readings stored in memory. The post process PFAIL operation is a batch operation. That is, the readings do not have to be recalled from memory in order to perform the PFAIL operation. Also notice that the readings must be stored before enabling the post process PFAIL operation (if not, the MEMORY ERROR will occur).

```

10  OUTPUT 722;"PRESET NORM"!PRESET,NRDGS 1,AUTO, DCV 10, TRIG SYN
20  OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
30  OUTPUT 722;"SMATH MIN 9"!LOWER LIMIT = 9(V)
40  OUTPUT 722;"SMATH MAX 11"!UPPER LIMIT = 11(V)
50  OUTPUT 722;"CSB" "!CLEAR STATUS REGISTER
60  OUTPUT 722;"RQS 2!ENABLE HI/LO STATUS REGISTER BIT
70  OUTPUT 722;"NRDGS 20"!20 READINGS/TRIGGER
80  OUTPUT 722;"TRIG SGL"!TRIGGER READINGS
90  OUTPUT 722;"MMATH PFAIL"!PERFORM POST-PROCESS PFAIL OPERATION
100 OUTPUT 722;"STB?";!QUERY SET BITS IN STATUS REGISTER
110 ENTER 722; A!ENTER QUERY RESPONSE
120 IF BINAND(A,2) THEN!IF BIT 2 IS SET:
130 PRINT "Hi/LOW LIMIT TEST FAILED"          !PRINT FAILURE MESSAGE
140 OUTPUT 722;"RMATH PFAILNUM"!QUERY PFAILNUM REGISTER
150 ENTER 722; B!ENTER QUERY RESPONSE
160 PRINT "NUMBER OF READINGS THAT PASSED BEFORE FAILURE WERE";B
165!PRINT PFAILNUM RESPONSE
170 ELSE!IF BIT 2 WAS NOT SET:
180 PRINT "HI/LOW LIMIT TEST PASSED"          !PRINT TEST PASSED MESSAGE
190 END IF
200 END

```

FILTER

The filter math operation simulates the output of a single pole, low pass, RC filter. This allows you to reduce the effects of random noise while preserving long term trends. The equation is:

$$\text{Result} = (\text{Previous Result}) \times (\text{DEGREE} - 1) / \text{DEGREE} + \text{Reading} / \text{DEGREE}$$

Where:

Previous Result is initially set to the value of the first reading and thereafter is set to the result of this FILTER operation.

Reading is any reading.

DEGREE selects the step response of the filter.

The value of DEGREE corresponds to the step response of the low-pass filter. That is, if 20 is the value of DEGREE, 20 readings are required for the step response to achieve 63% of its final value. You can achieve slower response or quieter readings by increasing the value of DEGREE. The actual time constant ($R \times C$) of the filter can be determined by:

$$t = \frac{1}{f_s} \left[\frac{1}{\ln \frac{\text{DEGREE}}{\text{DEGREE} - 1}} - 1 \right]$$

Where:

t = the time constant ($R \times C$)

f_s = the sampling rate which is: 1/timer interval (when using the TIMER and NRDGS commands) or 1/effective interval (when using the SWEEP command). If you are not using the TIMER or SWEEP command, refer to "Determining the Reading Rate" earlier in this chapter.

If DEGREE is larger than 10, ($R \times C$) can be approximated by:

$$t \approx (1/f_s) \times \text{DEGREE}$$

For example (using the first equation), if the reading rate is 200 Hz and the DEGREE is 20, the time constant is:

$$t = \frac{1}{200} \left[\frac{1}{\ln \frac{20}{20 - 1}} - 1 \right] = 0.092 \text{ Seconds}$$

Using the second equation with the same reading rate and DEGREE produces:

$$t \approx (1/200) \times 20 = 0.1 \text{ seconds}$$

RMS

The RMS math operation can be used to compute the combined RMS value of the AC and DC components of digitized (using the DCV, DSAC, or DSDC command) low frequency signals.

NOTE

For repetitive AC signals of 1 Hz or greater, the synchronous AC measurement method can be used instead of the RMS math operation. If the AC signal is 10 Hz or greater, the analog AC method can be used. If the signal is 20 Hz or greater, the random method can be used. You can also determine the RMS value of the AC component of sinewaves by digitizing (using the DCV, DSAC, or DSDC command) and enabling the STATS math operation. After a number of readings, the result in the SDEV register is the RMS value of the AC component of the input signal.

The RMS math operation takes the square root of the preceding FILTER operation with the reading and the previous result first squared. The RMS math equation is:

$$\text{Result} = \sqrt{\frac{\text{PreviousResult}^2 \cdot (\text{DEGREE} - 1)}{\text{DEGREE} + \frac{\text{Reading}^2}{\text{DEGREE}}}}$$

Where:

Previous Result is initially set to the value of the first reading and thereafter is set to the result of this FILTER operation.

Reading is the latest reading taken.

DEGREE selects the step response of the filter.

Measuring temperature

The temperature-related math operations convert the measured resistance of a thermistor or RTD into a Fahrenheit or Celsius temperature reading. [Table 4-6](#) describes each of the temperature-related math operations. The resistance measurement can be made in either 2-wire ohms (OHM command) or 4-wire ohms (OHMF command). For the greatest accuracy, use the 4-wire ohms mode. Conditions that affect the accuracy of a typical resistance measurement also affect the accuracy of temperature measurements (see [Resistance](#) and [Calibration](#) in [Chapter 3](#)).

Table 4-6 Temperature-related math operations

MATH operation	Description
CTHRM2K	Result = temperature (Celsius) of a 2 k Ω thermistor (40653A)
CTHRM	Result = temperature (Celsius) of a 5 k Ω thermistor (40653B)
CTHRM10K	Result = temperature (Celsius) of a 10 k Ω thermistor (40653C)
FTHRM2K	Result = temperature (Fahrenheit) of a 2 k Ω thermistor (40653A)
FTHRM	Result = temperature (Fahrenheit) of a 5 k Ω thermistor (40653B)
FTHRM10K	Result = temperature (Fahrenheit) of a 10 k Ω thermistor (40653C)
CRTD85	Result = temperature (Celsius) of 100 Ω RTD with alpha of 0.00385 (40654A or 406548)
CRTD92	Result = temperature (Celsius) of 100 Ω RTD with alpha of 0.003916
FRTD85	Result = temperature (Fahrenheit) of 100 Ω RTD with alpha of 0.00385 (40654A or 40654B)
FRTD92	Result = temperature (Fahrenheit) of 100 Ω RTD with alpha of 0.003916

The following example performs a temperature measurement using a 10 k Ω thermistor and returns the result in degrees Celsius.

```
10 OUTPUT 722;"PRESET NORM"!PRESETS MULTIMETER, SUSPENDS READINGS
20 OUTPUT 722;"OHMF 10E3"!SELECTS 4-WIRE OHMS, 10 k $\Omega$  RANGE
30 OUTPUT 722;"MATH CTHRM10K"!CELSIUS CONVERSION, 10 k $\Omega$  THERMISTOR
40 OUTPUT 722;"TRIG SGL"!TRIGGER READING
50 ENTER 722;A!ENTER RESULT
```

4 Making Measurements

```
60 PRINT A!PRINT RESULT
70 END
```

5 Digitizing

Introduction	192
Digitizing Methods	193
The Sampling Rate	195
Level Triggering	197
DCV Digitizing	201
Direct-Sampling	205
Sub-Sampling	209
Viewing Sampled Data	218

Introduction

Digitizing is the process of converting a continuous analog signal into a series of discrete samples (readings). **Figure 5-1** shows the result of digitizing a sine wave. This chapter discusses the various ways to digitize signals. The importance of the sampling rate, and how to use level triggering.

NOTE

As a supplement to the information in this chapter, Product Note 3458A-2 in **Appendix D** discusses the trigger and timebase errors that affect digitized measurements.

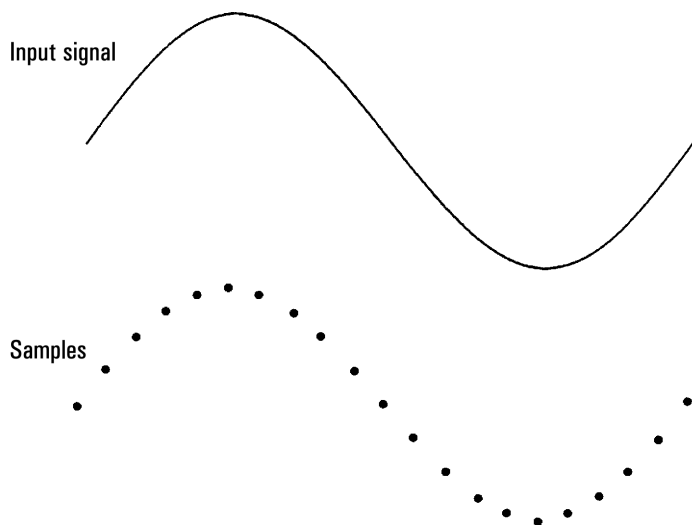


Figure 5-1 Digitized sine wave

Digitizing Methods

The multimeter can digitize signals by making DC voltage measurements, by direct-sampling, or by sub-sampling. [Table 5-1](#) summarizes the characteristics of each digitizing method. [Figure 5-2](#) shows a simplified block diagram of the multimeter's signal path for each digitizing method. [Figure 5-3](#) and shows the front terminal connections for all methods of digitizing.

Table 5-1 Digitizing methods

Digitizing method	Maximum sampling rate	Band width	Repetitive signal required
DCV	100 k/sec	DC - 150 kHz ^[a]	No
Direct-Sampling	50 k/sec	DC - 12 MHz	No
Sub-Sampling	100 M/sec ^[b]	DC - 12 MHz	Yes

[a] Range dependent. See the ["Appendix A: Specifications"](#) on page 409 for details.

[b] Effective sampling rate (refer to [Sub-Sampling](#) later in this chapter for details).

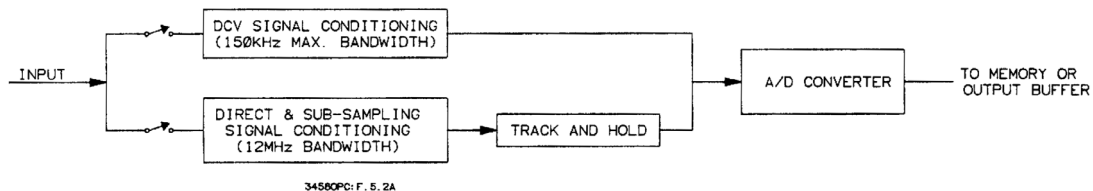


Figure 5-2 Digitizing signal paths

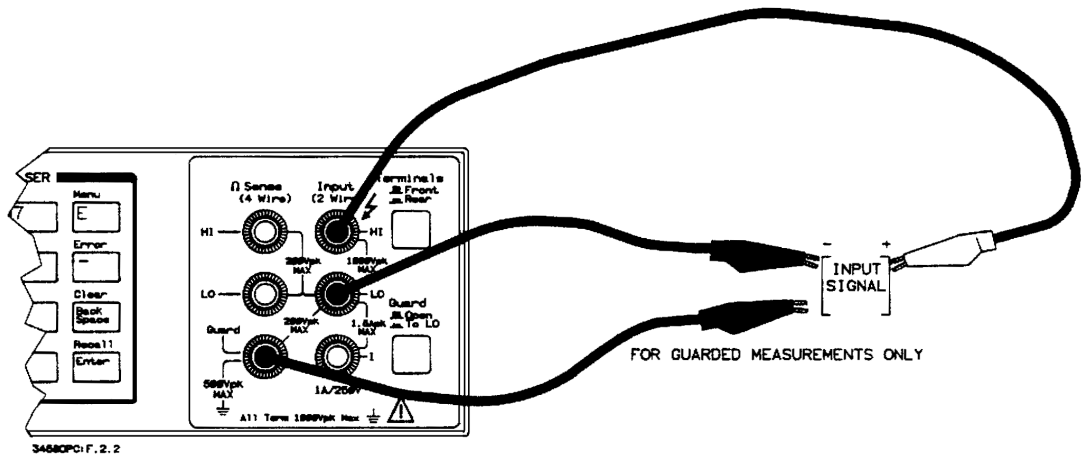


Figure 5-3 Digitizing measurement connections

For most digitizing applications, the multimeter enters its high-speed mode whenever sampling is initiated. In the high-speed mode, the multimeter becomes completely dedicated to taking samples. This means that it will not process any commands until the specified number of samples are completed. When samples are sent directly to the output buffer in the high-speed mode, the multimeter waits until each sample is removed from the output buffer before placing the next sample in the output buffer. This ensures that samples will not be lost because of bus/controller speed limitations. (When not in the high-speed mode, the multimeter writes-over any sample still in the output buffer when a new sample is available.) For more information, refer to [High-speed mode](#) in [Chapter 4](#).

The Sampling Rate

The Nyquist or Sampling Theorem states:

If a continuous, bandwidth-limited signal contains no frequency components higher than F , then the original signal can be recovered without distortion (aliasing) if it is sampled at a rate that is greater than $2F$ samples per second.

In practice, the multimeter's sampling rate must be at *least* twice the highest frequency component of the signal being measured. The sampling rate is the reciprocal of the time interval specified by the `TIMER` command or the *effective_interval* specified by the `SWEEP` command. For example, assume the *effective_interval* is specified as $20\ \mu\text{s}$. The sampling rate is then $1/20\ \mu\text{s} = 50,000$ samples per second.

Figure 5-4 shows a sine wave sampled at a rate slightly less than $2F$. As shown by the dashed line, the result is an *alias frequency* which is much different than the frequency of the signal being measured.

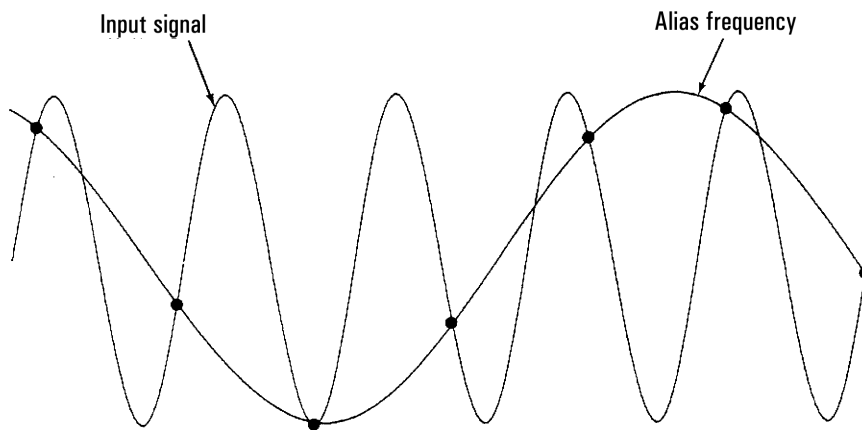


Figure 5-4 Aliasing caused by undersampling

Some digitizers have a built-in anti-aliasing low-pass filter with a sharp cutoff at a frequency equal to $1/2$ the digitizer's sampling rate. This limits the bandwidth of the input signal so that aliasing cannot occur. Since the multimeter has a variable sample rate for DCV digitizing, and to preserve the upper bandwidth for high-frequency measurements, no anti-aliasing filter is provided in the multimeter. If you are concerned about aliasing, you should add an external antialiasing filter.

Level Triggering

When digitizing, it is important to begin sampling at some defined point on the input signal such as when the signal crosses zero volts or when it reaches the midpoint of its positive or negative peak amplitude. Level triggering allows you to specify when (with respect to voltage and slope) to begin sampling. For example, [Figure 5-5](#) shows sampling beginning as the input signal crosses 0 V with a positive slope.

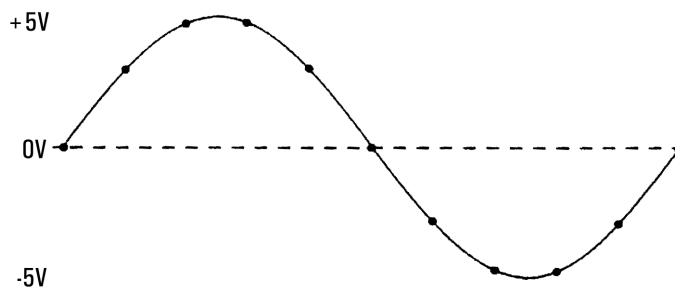


Figure 5-5 Level triggering at zero crossing, positive slope

Level triggering examples

For DCV and direct sampling, level triggering can be used as the trigger event (TRIG LEVEL command) or the sample event (NRDGS n, LEVEL command). For sub-sampling, level triggering can be used as the sync source event only (the sync source event is discussed later in this chapter under [Sub-Sampling](#)). The program examples in this section use the DCV method of digitizing and the 10 V range. Refer to [DCV Digitizing](#), [Direct-Sampling](#), and [Sub-Sampling](#) later in this chapter, for complete programs showing specific information on how to use level triggering with each digitizing method.

The LEVEL command specifies the level triggering voltage as a percentage of the measurement range. {The ranges are shown later in this chapter under the discussions for each digitizing method,} The LEVEL command also specifies the coupling (AC or DC) to the level detection circuitry.

NOTE

The coupling of the input signal can affect the level trigger coupling. That is, if you select AC coupling for the input signal (e.g., DSAC or SSAC) the level trigger signal will also be AC coupled regardless of the specified level trigger coupling. When the input signal is DC coupled (e.g., DCV, DSDC, SSDC) however, you can control the coupling of the level trigger signal with the LEVEL command. The level trigger coupling does not affect the input signal coupling.

The SLOPE command specifies the slope of the signal to use. The power-on or default values for these commands specify a level percentage of 0% of the present range (trigger when the signal crosses zero volts), positive slope, and AC-coupling to the level detection circuitry. So, in the power-on state, you can select the level triggering shown in [Figure 5-6](#) merely by specifying the LEVEL trigger event (TRIG LEVEL command).

The following program specifies level triggering to occur when the input signal reaches +5 V (50% of the 10 V range) on a negative slope (AC-coupled). Assuming the input signal has a peak value of 10 V and the measurement range is 10 V, the result is shown in [Figure 5-6](#).

```
100OUTPUT 722;"PRESET DIG" !DCV DIGITIZING, 10 V RANGE
200OUTPUT 722;"TRIG LEVEL" !SELECT LEVEL TRIGGER EVENT
300OUTPUT 722;"SLOPE NEG"!TRIGGER ON NEGATIVE SLOPE OF SIGNAL
400OUTPUT 722;"LEVEL 50, AC" !LEVEL TRIGGER AT 50% OF 10 V RANGE,
45!AC-COUPLED
50END
```

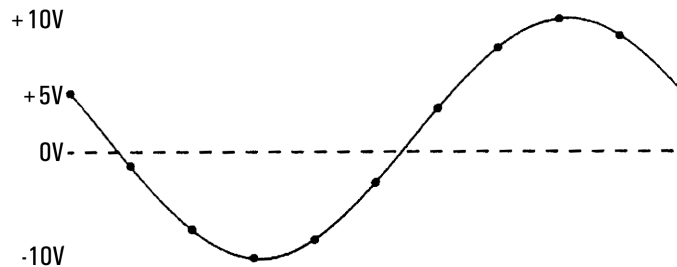


Figure 5-6 Level triggering, 50%, neg. slope, AC-coupled

The following program specifies level triggering to occur when the input signal reaches -5 V (-50% of the 10 V range) on a positive slope (AC-coupled). Assuming the input signal has a peak value of $\pm 10\text{ V}$ and the measurement range is 10 V , the result is shown in [Figure 5-7](#).

```
100OUTPUT 722;"PRESET DIG" !DCV DIGITIZING, 10 V RANGE
200OUTPUT 722;"TRIG LEVEL" !SELECT LEVEL TRIGGER EVENT
300OUTPUT 722;"SLOPE POS"!TRIGGER ON POSITIVE SLOPE OF SIGNAL
400OUTPUT 722;"LEVEL -50,AC"!LEVEL TRIGGER AT -50% OF 10 V RANGE,
45!(-5 V) AC-COUPLED
50END
```

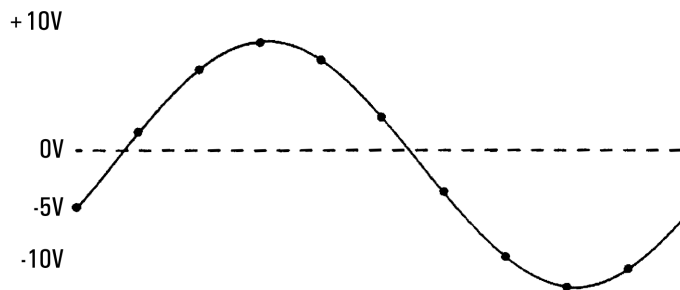


Figure 5-7 Level triggering, -50%, pos. slope, AC-coupled

In the following program the input signal is DC-coupled to the level detection circuitry and consists of a 5 V peak AC signal riding on a -5 V DC level. In this case, a negative percentage of the range (-25%) is used to level trigger at -2.5 V. positive slope. **Figure 5-8** shows the result.

```
10OUTPUT 722;"PRESET DIG" !DCV DIGITIZING, 10 V RANGE
20OUTPUT 722;"TRIG LEVEL" !LEVEL TRIGGER EVENT
30OUTPUT 722;"SLOPE POS" !TRIGGER ON POSITIVE SLOPE OF SIGNAL
40OUTPUT 722;"LEVEL - 25, DC" !LEVEL TRIGGER AT -25% OF 10 V RANGE
45!DC coupled
50 END
```

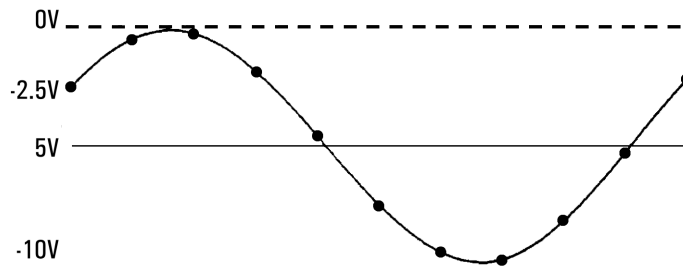


Figure 5-8 Level triggering, -25%, pos. slope, DC-coupled

Level filtering

When enabled, the level filter function connects a single-pole low-pass filter circuit to the input of the level-detection circuitry. The low-pass filter has a 3 dB point of 75 kHz and prevents high frequency components on the input signal from causing false triggers. To enable level filtering, send:

```
OUTPUT 722; "LFILTER ON"
```

NOTE

The level filter function can also reduce the multimeter's sensitivity to high frequency noise for frequency and period measurements or when making synchronous (SETACV SYNC) ACV or ACDCV measurements.

DCV Digitizing

Digitizing can be done simply by specifying DC voltage measurements with a short integration time and a short interval between samples ("short" relative to the frequency of the signal being digitized). This is considered digitizing although the multimeter's track-and-hold circuit is not used. The advantages of DCV digitizing over direct-sampling (discussed later) are a lower noise level, higher resolution (up to 28 bits), and a maximum sampling rate of 100,000 samples per second (versus 50,000 for direct-sampling). The disadvantages of DCV digitizing are a greater amount of trigger jitter (see the "Appendix A: Specifications" on page 409), the inability to AC-couple the input signal, and a lower bandwidth input path of 150 kHz (vs. 12 MHz for direct- or sub-sampling). Since the track-and-hold circuit is not used for DCV digitizing, each sample is much wider (a minimum of 500 nanoseconds versus 2 nanoseconds for direct- or sub-sampling).

The PRESET DIG command configures the multimeter for DC voltage measurements with a sampling rate of 50,000 samples per second. PRESET DIG selects a 3 μ s integration time and level triggering when the input signal crosses zero volts on its positive slope. The primary commands executed by PRESET DIG are:

```
TARM HOLD -- Suspends triggering
TRIG LEVEL -- LEVEL trigger event
LEVEL 0,AC -- Level trigger at 0% of range (0 V), AC-coupled
TIMER 20E-6 -- 20  $\mu$ s interval between samples
NRDGS 256,TIMER -- 256 samples per trigger, TIMER sample event
DCV 10 -- DC voltage measurements, 10 V range
DELAY 0 -- No delay
APER 3E-6 -- 3  $\mu$ s integration time
MFORMAT SINT -- Single integer memory format
OFORMAT SINT -- Single integer output format
AZERO OFF -- Disables the autozero function
DISP OFF -- Disables the display
```

After executing PRESET DIG, you can increase the sampling rate by decreasing the TIMER interval and by reducing the integration time using the APER command. The minimum integration time for DCV is 500 nanoseconds.

DCV remarks

- For DCV digitizing, you should use the SINT memory/output format when the integration time is $\leq 1.4 \mu\text{s}$. Use the DINT memory/output format when the integration time is $> 1.4 \mu\text{s}$. (These formats are discussed in detail in [Chapter 4](#).)

NOTE

To achieve the fastest possible transfer of samples to reading memory and/or the controller, you can use the SINT output/memory format for integration times up to $10.8 \mu\text{s}$. However when the integration time is $> 1.4 \mu\text{s}$, the A/D converter is producing more bits of resolution than can be accommodated by the SINT format (the least significant bit(s) are discarded). Whenever using the SINT output/memory format with integration times $> 10.8 \mu\text{s}$, the multimeter must convert the data coming from the A/D converter and cannot maintain the high-speed mode. You should use the DINT memory/output format (which is compatible with the high-speed mode) when the integration time is $> 10.8 \mu\text{s}$.

- Whenever making measurements using the TIMER sample event or the SWEEP command, autorange is disabled. You can use the range selected by PRESET DIG (10 V range) or specify the range as the first parameter of the DCV or RANGE command (*max_input* parameter). The *max_input* parameters and the ranges they select are:

<i>max_input</i> parameter	Selects range	Full scale
0 to .12	100 mV	120 mV
>.12 to 1.2	1 V	1.2 V
>1.2 to 12	10 V	12 V
>12 to 120	100 V	120 V
>120 to 1E3	1000 V	1050 V

- The multimeter's triggering hierarchy (trigger arm event, trigger event, and sample event) applies to DCV digitizing. Refer to [Chapter 4](#) for more information on the triggering hierarchy. For DCV digitizing, you can use either the TIMER sample event and the NRDGS *n*,TIMER command: or the SWEEP command. The NRDGS and SWEEP commands are interchangeable, the

multimeter uses whichever command was specified last. (When using the SWEEP command, the sample event is automatically set to TIMER.)

- Aperture time is the time when the multimeter is actually sampling the input signal. For direct- and sub-sampling using the track-and-hold, the aperture time is fixed at 2 ns and cannot be changed. For DCV digitizing, the aperture time is equal to the A/D converter's integration time and can be varied from 500 ns to 1 s. The multimeter effectively averages the input signal during its aperture time. An amplitude error is introduced when the signal is changing during the aperture time. [Table 5-2](#) shows the input signal frequencies where 3 dB of amplitude error occurs for selected aperture times and the bits of resolution produced for these aperture times.

Table 5-2 Amplitude error and resolution vs. aperture

Aperture time	Bits of resolution	Frequency For 3 dB error
2 ns	16	100 MHz
500 ns	15	400 kHz
1 μ s	16	206 kHz
3 μ s	17	69 kHz
6 μ s	18	35 kHz
100 μ s	21	2 kHz

DCV example

The following program takes 256 DC voltage samples at a rate of 100,000 samples per second and places them in reading memory using SINT format. The samples are then transferred to the controller using the SINT output format. The controller converts the samples from SINT format and stores the samples. By deleting line 100, samples will be transferred directly to the controller instead of using reading memory. However, the controller and GPIB must be able to transfer samples at a rate of at least 200k-bytes/second or the multimeter will generate the TRIGGER TOO FAST error. Refer to [High-speed transfer across GPIB](#) in [Chapter 4](#) for more information.

```

100OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20Num_samples=256!SPECIFY NUMBER OF SAMPLES
30INTEGER Int_samp(1:256) BUFFER!CREATE INTEGER BUFFER
40ALLOCATE REAL Samp(1:Num_samples)!CREATE REAL ARRAY FOR SAMPLES
50ASSIGN @Dvm TO 722!ASSIGN MULTIMETER ADDRESS
60ASSIGN @Int_samp TO BUFFER Int_samp(*)!ASSIGN I/O PATH NAME TO BUFFER
70OUTPUT @Dvm;"PRESET DIG"!TARM HOLD, DCV, 10 V RANGE, 256 SAMPLES
71!PER TRIGGER, TIMER SAMPLE EVENT, TIMER INTERVAL = 20  $\mu$ s, TRIG
75!LEVEL (0%, AC-COUPLED), 3  $\mu$ s INTEGRATION TIME, SINT FORMATS
80OUTPUT @Dvm;"TIMER 10E-6"!10  $\mu$ s INTERVAL BETWEEN SAMPLES
90OUTPUT @Dvm;"APER 1.4E-6"!MAXIMUM APERTURE FOR 100 KHZ SAMP. RATE
100OUTPUT @Dvm;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
110OUTPUT @Dvm; "TARM SYN"!SYNCHRONOUS TRIGGER ARM EVENT
120TRANSFER @Dvm TO @Int_samp;WAIT!SYN EVENT,TRANSFER READINGS INTO
121!READING MEMORY AND THEN INTO AN INTEGER ARRAY IN THE COMPUTER;
122!SINCE THE COMPUTER'S INTEGER FORMAT IS THE SAME AS SINT, NO DATA
123!CONVERSION IS NECESSARY HERE (INTEGER ARRAY REQUIRED)
130OUTPUT @Dvm; "ISCALE?"!QUERY SCALE FACTOR FOR SINT FORMAT
140ENTER @Dvm;S!ENTER SCALE FACTOR
150FOR I=1 TO Num_samples
160  Samp(I)=Int_samp(I)!CONVERT EACH INTEGER READING TO REAL
165  !FORMAT (NECESSARY TO PREVENT POSSIBLE INTEGER OVERFLOW ON NEXT
    LINE)
170  R=ABS(Samp(I))!USE ABSOLUTE VALUE TO CHECK FOR OVLD
180  IF R>=32767 THEN PRINT "OVLD"!IF OVLD, PRINT OVERLOAD MESSAGE
190  Samp(I)=Samp(I)*S!MULTIPLY READING TIMES SCALE FACTOR
200  Samp(I)=DROUND(Samp(I),4)!ROUND TO 4 DIGITS
210NEXT I
220END

```


Direct-Sampling

Direct-sampling is similar to DCV digitizing in that samples are taken in real-time with each successive sample spaced a specified time interval from the preceding sample. The difference between the two is that direct sampling uses the multimeter's track-and-hold circuit and has a wider bandwidth input path (12 MHz bandwidth). In addition, direct sampling has less trigger jitter but greater measurement noise than DCV digitizing (see the ["Appendix A: Specifications"](#) on page 409).

The track-and-hold circuit takes a very fast sample of the input signal and then holds the value while the A/D converter integrates it. By using the track and hold circuit, the width of each sample is reduced from a minimum of 500 nanoseconds for DCV to 2 nanoseconds for direct-sampling. This makes direct sampling ideal for applications such as capturing the peak amplitude of a narrow pulse. The disadvantage of direct-sampling is a slower maximum sampling rate of 50,000 samples per second versus 100,000 for DC voltage.

You specify direct sampling using the DSAC or DSDC command. The DSAC command selects AC-coupling, which measures only the AC component of the input signal. The DSDC command selects DC-coupling, which measures the combined AC and DC components of the input signal.

[Figure 5-9](#) shows 20 samples made using direct sampling on a sine wave input (the numbers indicate the order in which the samples were taken). With direct sampling, the minimum possible interval between samples is 20 μs .

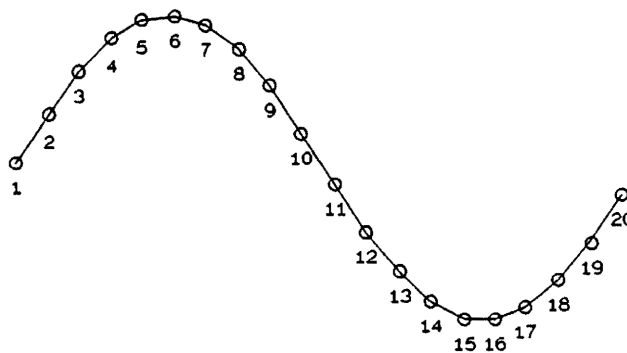


Figure 5-9 Direct sampling

Direct sampling remarks

- You cannot use autorange for direct-sampled measurements; you must specify the range as the first parameter of the DSAC or DSDC command (*max._input* parameter). The *max._input* parameters and the ranges they select are:

<i>max._input</i> parameter	Selects range	Full scale	
		SINT format	DINT format
0 to .012	10 mV	12 mV	50 mv
>.012 to .120	100 mV	120 mV	500 mV
>.120 to 1.2	1 V	1.2 V	5.0 V
>1.2 to 12	10 V	12 V	50 V
>12 to 120	100 V	120 V	500 V
>120 to 1E3	1000 V	1050 V	1050 V

Notice that when using the DINT memory/output format, the full scale values for direct-sampling are 500% (5 times) the ranges of 10 mV, 100 mV, 1 V, 10 V, and 100 V. This is particularly important to consider when specifying the percentage for level triggering. When specifying the level triggering voltage, use a percentage of the range. For example, assume the input signal has a peak value of 20 V and you are using the 10 V range. If you want to level trigger at 15 V specify a level triggering percentage of 150% (LEVEL 150 command). (The slew rate of the multimeter's amplifiers may be exceeded when measuring a signal with a frequency >2 MHz and an amplitude >120% of range; signals ≤120% of range with frequencies up to 12 MHz do not cause slew rate errors.)

- The multimeter's triggering hierarchy (trigger arm event, trigger event, and sample event) applies to direct-sampling. This means that these events must occur in the proper order before direct sampling begins. Refer to [Chapter 4](#) for more information on the triggering hierarchy. For direct sampling, you can use either the TIMER sample event and the NRDGS *n*,TIMER command; or the SWEEP command (SWEEP is the simpler to program). The NRDGS and SWEEP commands are interchangeable; the multimeter uses whichever command was specified last. (When using the SWEEP command, the sample event is automatically set to TIMER.)

- When direct-sampling an input signal with a frequency content ≥ 1 MHz, the first sample may be in error because of interpolator settling time. To ensure the first sample is accurate, insert a 500 ns delay before the first sample (DELAY 500E-9 command).

Direct sampling example

The following program is an example of DC-couple direct-sampled digitizing. The SWEEP command specifies an interval of 30 μ s and 200 samples. Level triggering is set for 250% of the 10 V range (250% of 10 V = 25 V). The samples are sent to reading memory in DINT format. The samples are then sent to the controller, converted, and printed. By deleting line 110, samples will be transferred directly to the controller instead of using reading memory. However, the controller and GPIB must be able to transfer samples at a rate of at least 134k-bytes/second or the multimeter will generate the TRIGGER TOO FAST error. Refer to [High-speed transfer across GPIB](#) in [Chapter 4](#) for more information.

```

100OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20INTEGER Num_samples,I,J,K!CREATE INTEGER VARIABLES
30Num_samples = 200!200 SAMPLES
35ASSIGN @Dvm TO 722!DESIGNATE MULTIMETER ADDRESS
40ASSIGN @Buffer TO BUFFER [4*Num_samples]!SETUP CONTROLLER BUFFER FOR
45!SAMPLES, (4-BYTES/SAMPLE * 200 SAMPLES = 800 BYTES)
50ALLOCATE REAL Samp(1:Num_samples)!CREATE REAL ARRAY FOR SAMPLES
60OUTPUT @Dvm;"PRESET FAST"!DINT FORMATS, TARM SYN, TRIG AUTO
70OUTPUT @Dvm;"SWEEP 30E - 6,200"!30  $\mu$ s INTERVAL, 200 SAMPLES
80OUTPUT @Dvm;"DSDC 10"!DIRECT-SAMPLING, 10 V RANGE
90OUTPUT @Dvm;"LEVEL 250, DC"!LEVEL TRIGGER AT 250% OF RANGE (25 V)
100OUTPUT @Dvm;TRIG LEVEL"!LEVEL TRIGGER EVENT
110OUTPUT @Dvm;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
120TRANSFER @Dvm TO @Buffer;WAIT!TRANSFER SAMPLES TO CONTROLLER
130OUTPUT @Dvm;"ISCALE?"!QUERY SCALE FACTOR FOR DINT FORMAT
140ENTER @Dvm;S!ENTER SCALE FACTOR
150FOR I=1 TO Num_samples

```

```
160 ENTER @Buffer USING "#,W,W";J,K!ENTER ONE 16-BIT 2'S COMPLEMENT
161 !WORD INTO EACH VARIABLE J AND K (# = STATEMENT TERMINATION NOT
165 !REQUIRED; W = ENTER DATA AS 16-BIT 2'S COMPLEMENT INTEGER)
170 Samp(I)=(J*65536.+K+65536.*(K<0))!CONVERT TO REAL NUMBER
180 R=ABS(Samp(I))!USE ABSOLUTE VALUE TO CHECK FOR OVLD
190 IF R>2147483647 THEN PRINT "OVLD"!IF OVERLOAD OCCURRED, PRINT
MESSAGE
200 Samp(I)=Samp(I)*S!APPLY SCALE FACTOR
210 Samp(I)=DROUND(Samp(I),8)!ROUND CONVERTED READING
220 PRINT Samp(I)!PRINT READINGS
230NEXT I
240END
```

Sub-Sampling

In sub-sampling (also known as sequential-sampling), the multimeter takes one or more samples on each period of the input signal. With each successive period, the beginning sample point is delayed further-and more samples are taken. After a number of periods have occurred and the specified number of samples have been taken, the samples can be reconstructed to form a composite waveform with a period equal to that of the input signal.

The advantage of sub-sampling is that samples can be effectively spaced at a minimum interval of 10 ns versus 10 μ s for DCV digitizing and 20 μ s for direct-sampling. This means that sub-sampling can be used to digitize signals with frequency components up to 12 MHz (the upper bandwidth of the signal path for sub-sampling). Sub-sampled measurements use the track-and-hold circuit, which has a 2 nanosecond aperture. Sub-sampling (and direct-sampling) have less trigger jitter than DCV digitizing (see the “[Appendix A: Specifications](#)” on page 409). The disadvantages of sub-sampling are that the input signal must be periodic (repetitive) and sub-sampling is not a real-time measurement.

You specify sub-sampling using the SSAC or SSDC command. The SSAC command selects AC-coupled sub-sampling which digitizes only the AC component of the input signal. The SSDC command selects DC-coupled sub-sampling, which digitizes the combined AC and DC components of the signal.

Sub-sampling fundamentals

In sub-sampling, the samples in the composite waveform can be spaced very closely together. This means that the interval between samples in the composite waveform (*effective_interval*) can be much smaller (and the effective sampling rate much greater) than in the DCV or direct-sampling methods. For example, assume you need to digitize a repetitive 10 kHz input signal with a 5 μ s *effective_interval* between samples. This is a sampling rate of 1/5E-6 or 200,000 samples per second, (This application would be impossible using DCV or direct-sampling since their maximum sampling rates are 100,000 and 50,000 samples per second, respectively.) [Figure 5-10](#) illustrates how this can be done using sub-sampling. The *effective_interval* is specified as 5 μ s and specified number of samples is 20. The *effective_interval* and the total number of samples are specified by the SWEEP command. After specifying the *effective_interval* and the number of samples, the multimeter calculates how many bursts (a burst is a group of samples) it needs to make and how many samples will be in each burst.

For this example, on the first period of the input signal, the multimeter takes a burst of 5 samples. On the second period, the multimeter delays the trigger point by $5\ \mu\text{s}$ and takes another burst of 5 samples. On each of the remaining two periods, the multimeter delays the trigger point by another $5\ \mu\text{s}$ and takes a burst of 5 samples. As shown in [Figure 5-11](#), when all the samples are arranged in the proper sequence, the result is one period of the input signal consisting of 20 samples spaced at $5\ \mu\text{s}$ intervals. In this example then, the *effective sampling rate* is 200,000 samples per second.

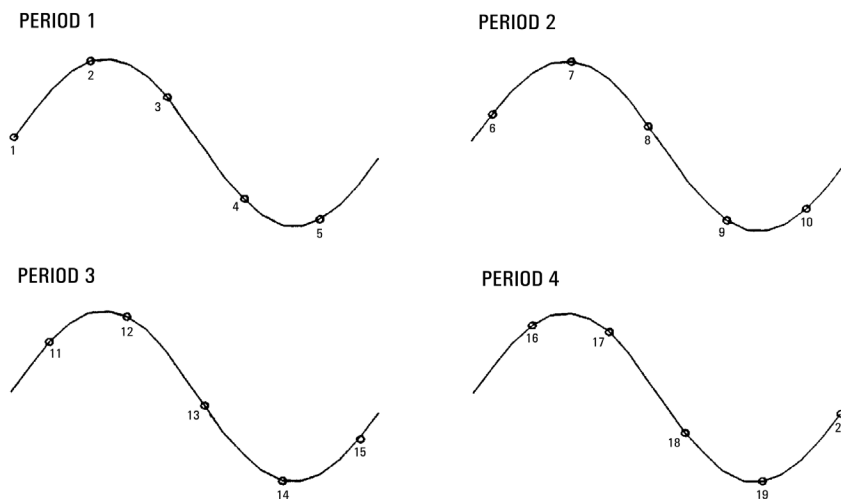


Figure 5-10 Sub-sampling example

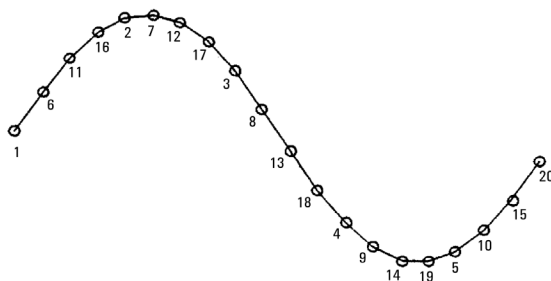


Figure 5-11 Composite waveform

The sync source event

In the preceding sub-sampling example, it was assumed that the multimeter could somehow synchronize itself to the periods of the input waveform. This is the function of the sync source event. You can use either the EXT event or the LEVEL event as the sync source event. The EXT sync source event (specified by the SSRC EXT command) occurs on the negative-edge transition on the multimeter's Ext Trig connector. This requires an external pulse that is synchronous with the input signal. **Figure 5-12** shows a typical input signal and the required synchronizing signal. Notice in **Figure 5-12** that the synchronizing signal does not necessarily have to occur once for every period of the input signal. It does, however, have to be synchronized in time with the input signal.

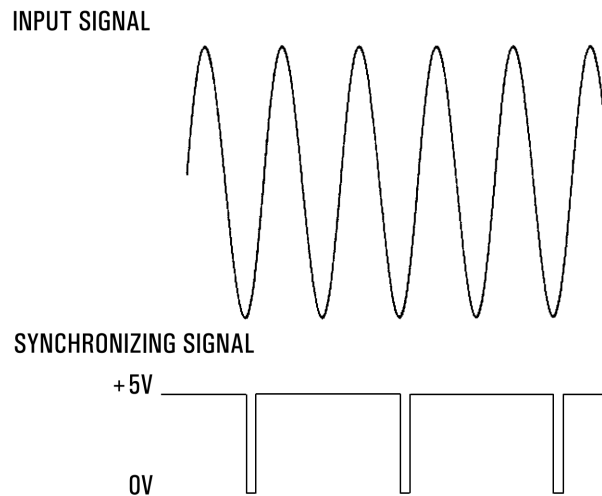


Figure 5-12 Typical synchronizing signal for EXT sync source

The LEVEL sync source event (which is the power-on/default sync source event) occurs when the input signal reaches a specified voltage level on the specified slope (level triggering). **Figure 5-10** shows the operation of the LEVEL sync source event (for this example, the LEVEL is specified as 0%, positive slope, AC-coupling). The first sync source event occurs when the input signal crosses 0 V with a positive slope. The multimeter then takes a burst of samples (5 samples in this case). Following the next occurrence of the sync source event (period 2 of the

input signal) the multimeter delays the trigger point and takes 5 more samples. This process repeats until the specified number of samples are completed.

In the following example, the SSDC command is used to digitize a 1 MHz signal with a peak value of 5 V riding on a 5 V DC level. The SWEEP command instructs the multimeter to take 4000 samples with a 10-nanosecond *effective_interval*. Lines 60 through 80 program the voltage level and the slope for the LEVEL sync source event. This will initiate sampling when the first period of the input signal reaches 7.5 VDC (75% of the 10 V range). Line 90 satisfies the trigger arm event, which essentially enables the sync source event.

```
100OUTPUT 722;"PRESET FAST"!TARM SYN, TRIG AUTO, DINT FORMATS
200OUTPUT 722;"MEM FIFO"!ENABLE READING MEMORY, FIFO MODE
300OUTPUT 722;"MFORMAT SINT"!SINT READING MEMORY FORMAT
400OUTPUT 722."SSDC 10"!SUB-SAMPLING, 10 V RANGE, LEVEL SYNC SOURCE
45 !EVENT (DEFAULT EVENT)
500OUTPUT 722;"SWEEP 10E-9,4000"!4000 SAMPLES, 10 ns EFFECTIVE INTERVAL
600OUTPUT 722;"LEVEL 75 DC"!LEVEL TRIGGER AT 75% OF RANGE, DC-COUPLED
700OUTPUT 722;"SLOPE POS"!LEVEL TRIGGER ON POSITIVE SLOPE
800OUTPUT 722;"SSRC LEVEL"!LEVEL SYNC SOURCE EVENT
900OUTPUT 722; "TARM SGL"!ENABLE SAMPLING
100END
```

Sub-sampling remarks

- For sub-sampling, the trigger event and sample event requirements are ignored (these events are discussed in [Chapter 4](#)). The only triggering events that apply to sub-sampling are the trigger arm event (TARM command) and the sync source event (SSRC command).
- You cannot use the NRDGS command for sub-sampling. You must use the SWEEP command to specify the number of samples and the *effective_interval*. The minimum *effective_interval* for sub-sampling is 10 nanoseconds. The maximum rate at which samples are taken is 50k samples per second (20 μ s between samples).

- You cannot use autorange for sub-sampled measurements; you must specify the range as the first parameter of the SSAC or SSDC command (*max._input* parameter). The *max._input* parameters and the ranges they select are:

<i>max._input</i> parameter	Selects range	Full scale
0 to .012	10 mV	12 mV
>.012 to .120	100 mV	120 mV
>.120 to 1.2	1 V	1.2 V
>1.2 to 12	10 V	12 V
>12 to 120	100 V	120 V
>120 to 1E3	1000 V	1050 V

As with direct sampling, you can specify a level triggering voltage up to 500% of the range. The required SINT format, however, cannot handle samples greater than 120% of range.

- If reading memory is disabled when you execute the SSAC or SSDC command, the multimeter automatically sets the output format to SINT (the memory format is not changed). Later, when you change to another measurement function, the output format returns to that previously specified. You must use the SINT output format when sub-sampling and outputting samples directly to the GPIB. You can however, use any output format if the samples are first placed in reading memory (see next remark). To do this, you should enable reading memory before executing the SSAC or SSDC command (executing SSAC or SSDC does not change the output format to SINT when reading memory is enabled).
- When sub-sampling with reading memory is enabled, reading memory must be in FIFO mode, must be empty (executing MEM FIFO clears reading memory), and the memory format must be SINT prior to the occurrence of the trigger arm event. If not, the multimeter generates the SETTINGS CONFLICT error when the trigger arm event occurs and no samples are taken.
- When sub-sampling an input signal with a frequency content ≥ 1 MHz, the first sample may be in error because of interpolator settling time. To ensure the first sample is accurate, insert a 500 ns delay using the DELAY 500E-9 command.

(When sub-sampling, the delay is inserted between the sync source event and the first sample in each burst; the default delay for sub-sampling is 0 seconds.)

Sending samples to memory

When samples are sent directly to reading memory (MEM FIFO command), the multimeter automatically re-orders the samples producing a composite waveform. For example, in the following program, the sub-sampled data is sent to reading memory using the required SINT memory format. The multimeter places the samples in memory in the corrected order. The samples are then transferred to the controller using the DREAL output format (when placing sub-sampled data in reading memory first, you are not restricted to using the SINT output format).

```

10OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20REAL Samp(1:200) BUFFER!CREATE BUFFER ARRAY
30ASSIGN @Dvm TO 722!ASSIGN MULTIMETER ADDRESS
40ASSIGN @Samp TO BUFFER Samp(*) !ASSIGN BUFFER
50OUTPUT @Dvm;"PRESET FAST"!TARM SYN, TRIG AUTO, DINT FORMATS
60OUTPUT @Dvm;"MEM FIFO"!FIRST-IN-FIRST-OUT READING MEMORY
70OUTPUT @Dvm;"MFORMAT SINT"!SINT MEMORY FORMAT
80OUTPUT @Dvm;"OFORMAT DREAL"!DOUBLE REAL OUTPUT FORMAT
90OUTPUT @Dvm;"SSDC 10"!SUB-SAMPLING, 10 V RANGE, DC-COUPLED
100OUTPUT @Dvm;"SWEEP 5E-6,200"!5 µs EFF. INTERVAL, 200 SAMPLES
110TRANSFER @Dvm TO @Samp;WAIT!TRANSFER SAMPLES TO CONTROLLER BUFFER
120FOR I=1 TO 200
130 IF ABS(Samp(I))=1E+38 THEN!DETECT OVERLOAD
140   PRINT "Overload Occurred"!PRINT OVERLOAD MESSAGE
150 ELSE!IF NO OVERLOAD OCCURRED:
160   Samp(I)=DROUND(Samp(I),5)!ROUND TO 5 DIGITS
170   PRINT Samp(I)!PRINT EACH SAMPLE
180 END IF
190NEXT I
200END

```

Sending samples to the controller

When samples are sent directly to the controller, an algorithm must be used to re-order the samples and produce the composite waveform. The SSPARM? command returns three parameters for the algorithm. The first parameter returned is the number of bursts measured that contained N samples. The second parameter returned is the number of bursts measured that contained $N-1$ samples. The third parameter returned is the value of N . For example, assume you are sub-sampling a 10 kHz signal and specify 22 samples with an *effective_interval* of 5 μ s. In this example, the multimeter takes 2 bursts containing 6 samples each and 2 bursts containing 5 samples each. Each burst is delayed 5 μ s from the previous burst. The values returned by SSPARM? are then 2, 2, and 6.

When sub-sampling, the maximum sample rate is 50k samples per second regardless of the specified *effective_interval*. (If you specify an *effective_interval* of ≥ 20 μ s, the multimeter is no longer sub-sampling but direct-sampling.) When sending samples directly to the controller (using the required SINT format which is 2-bytes per sample) the GPIB/controller must be able to handle the data at a maximum rate of 100k-bytes per second. If not, the multimeter generates the TRIGGER TOO FAST error.

In the program on the following page, the SSAC command is used to digitize a 10 kHz signal with a peak value of 5 V. The SWEEP command instructs the multimeter to take 1000 samples (Num_samples variable) with a 2 μ s *effective_interval* (Eff_int variable). The measurement uses the default level triggering for the sync source event (trigger from input signal, 0%, AC-coupling, positive slope). Line 110 generates a SYN event and transfers the samples directly to the computer. Lines 230 through 400 sort the sub-sampled data to produce the composite waveform. The composite waveform is stored in the Wave_form array.

```

100OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20INTEGER Num_samples,Inc,I,J,K,L!DECLARE VARIABLES
30Num_samples=1000!DESIGNATE NUMBER OF SAMPLES
40Eff_int=2.0E-6!DESIGNATE EFFECTIVE INTERVAL
50INTEGER Int_samp(1:1000) BUFFER!CREATE INTEGER BUFFER
60ALLOCATE REAL Wave_form(1:Num_samples) !CREATE ARRAY FOR SORTED DATA
70ALLOCATE REAL Samp(1:Num_samples)!CREATE ARRAY FOR SAMPLES
80ASSIGN @Dvm TO 722!ASSIGN MULTIMETER ADDRESS

```

```

90ASSIGN @Int_samp TO BUFFER Int_samp(*) !ASSIGN BUFFER I/O PATH NAME
100OUTPUT @Dvm;"PRESET FAST;LEVEL;SLOPE;SSDC 10;SWEEP
";Eff_int,Num_samples
101!FAST OPERATION, TARM SYN, DEFAULT LEVEL & SLOPE, SUB-SAMPLING (SINT
105!OUTPUT FORMAT), 10 V RANGE, 2  $\mu$ s EFFECTIVE INTERVAL, 1000 SAMPLES
110TRANSFER @Dvm TO @Int_samp;WAIT!SYN EVENT, TRANSFER READINGS INTO
111!INTEGER ARRAY; SINCE THE COMPUTER'S INTEGER FORMAT IS THE SAME AS
115! SINT, NO DATA CONVERSION IS NECESSARY HERE (INTEGER ARRAY REQUIRED)
120OUTPUT @Dvm; "I SCALE?"!QUERY SCALE FACTOR FOR SINT FORMAT
130ENTER @Dvm;!ENTER SCALE FACTOR
140OUTPUT @Dvm; "SSPARM?"!QUERY SUB-SAMPLING PARAMETERS
150ENTER @Dvm;N1,N2,N3!ENTER SUB-SAMPLING PARAMETERS
160FOR I=1 TO Num_samples
170 Samp(I)=Int_samp(I)!CONVERT EACH INTEGER READING TO REAL
175 !FORMAT (NECESSARY TO PREVENT POSSIBLE INTEGER OVERFLOW ON NEXT
LINE)
180 R=ABS(Samp(I))!USE ABSOLUTE VALUE TO CHECK FOR OVLD
190 IF R>=32767 THEN PRINT "OVLD"! IF OVLD, PRINT OVERLOAD MESSAGE
200 Samp(I)=Samp(I)*S!MULTIPLY READING TIMES SCALE FACTOR
210 Samp(I)=DROUND(Samp(I),4)!ROUND TO 4 DIGITS
220NEXT I
225 !-----SORT SAMPLES-----
230Inc=N1+N2!TOTAL NUMBER OF BURSTS
240K=1
250FOR I=1 TO N1
260 L=I
270 FOR J=1 TO N3
280 Wave_form(L)=Samp(K)
290 K=K+1
300 L=L+Inc
310 NEXT J

```

```
320NEXT I
330FOR I=N1+1 TO N1+N2
340  L=I
350  FOR J=1 TO N3-1
360    Wave_form(L)=Samp(K)
370    K=K+1
380    L=L+Inc
390  NEXT J
400NEXT I
410END
```

Viewing Sampled Data

The program on the following page plots digitized data to the controller's CRT (this particular program uses sub-sampling and the subroutine *Plot_it* does the actual plotting). This program is helpful when developing digitizing programs (especially when sub-sampling) since it allows you to see the data being captured. Since this program simply draws vectors between the samples (linear interpolation), it works well when the sampling rate is greater than 10 times the frequency of the signal being measured. If the sampling rate is less than 10 times the frequency of the input signal, this program will plot an incorrect representation of the input signal. Figure 5-13 shows a typical plot produced by this program.

NOTE

The 3458A Option 005 Waveform Analysis Library is a software package designed to capture and process digitized data. It contains routines that initialize the system, capture data, compare data, compute parameters on the data, perform Fourier transforms on the data, and plot/output the data. Contact your Keysight Sales Office for more information.

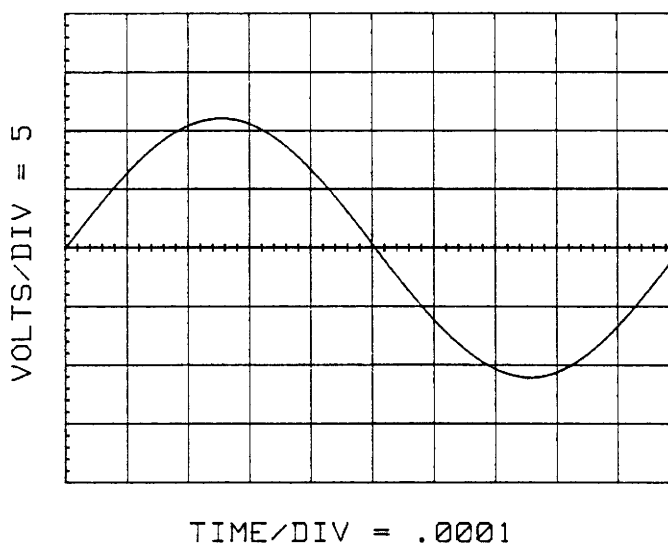


Figure 5-13 Typical plotted waveform

```

100OPTION BASE 1!COMPUTER ARRAY NUMBERING STARTS AT 1
20INTEGER Num_samples,Inc,I,J,K,L!DECLARE VARIABLES
30INTEGER Int_samp(1:1000) BUFFER!CREATE INTEGER BUFFER
40ALLOCATE REAL Wave_form(1:Num_samples)!CREATE ARRAY FOR SORTED DATA
50ALLOCATE REAL Samp(1:Num_samples)!CREATE ARRAY FOR SAMPLES
60Num_samples=1000!DESIGNATE NUMBER OF SAMPLES
70Eff_int=2.0E-6!DESIGNATE EFFECTIVE INTERVAL
80ASSIGN @Dvm TO 722!ASSIGN MULTIMETER ADDRESS
90ASSIGN @Int_samp TO BUFFER Int_samp(*)!ASSIGN I/O PATH NAME TO BUFFER
100OUTPUT @Dvm;"PRESET FAST;SSDC 10;SWEEP ";Eff_int, Num_samples
101!FAST OPERATION, TARM SYN, SUB-SAMPLING (SINT OUTPUT FORMAT), 10 V
RANGE
102!2  $\mu$ s EFFECTIVE INTERVAL, 1000 SAMPLES
110TRANSFER @Dvm TO @Int_samp;WAIT!SYN EVENT, TRANSFER READINGS
120OUTPUT @Dvm;"ISCALE?"!QUERY SCALE FACTOR FOR SINT FORMAT
130ENTER @Dvm;S!ENTER SCALE FACTOR
140OUTPUT @Dvm;"SSPARM?"!QUERY SUB-SAMPLING PARAMETERS
150ENTER @Dvm;N1,N2,N3!ENTER SUB-SAMPLING PARAMETERS
160FOR I=1 TO Num_samples
170  Samp(I)=Int_samp(I)!CONVERT EACH INTEGER READING TO REAL
175!FORMAT (NECESSARY TO PREVENT POSSIBLE INTEGER OVERFLOW ON NEXT LINE)
180  R=ABS(Samp(I))!USE ABSOLUTE VALUE TO CHECK FOR OVLD
190  IF R>=32767 THEN PRINT "OVLD"!IF OVLD, PRINT OVERLOAD MESSAGE
200  Samp(I)=Samp(I)*S!MULTIPLY READING TIMES SCALE FACTOR
210  Samp(I)=DROUND(Samp(I),4)!ROUND TO 4 DIGITS
220NEXT I
230Inc=N1+N2!Inc = TOTAL NUMBER OF BURSTS
240K=1!SORT SAMPLES
250FOR I=1 TO N1!  "
260  L=I!  "

```

```

270  FOR J=1 TO N3!      "
280    Wave_form(L)=Samp(K)!      "
290    K=K+1!      "
300    L=L+Inc!      "
310  NEXT J!      "
320NEXT I!      "
330FOR I=N1+1 TO N1+N2!      "
340  L=I!      "
350  FOR J=1 TO N3-1!      "
360    Wave_form(L)=Samp(K)!      "
370    K=K+1!      "
380    L=L+Inc!      "
390  NEXT J!      "
400NEXT I!      "
410DISP!CLEAR CONTROLLER CRT
420Time_div=1.0E-5 !TIME PER DIVISION FOR PLOT
430Volts_div=5!VOLTS PER DIVISION FOR PLOT
440Plot_it(Time_div,Volts_div,Wave_form(*),Eff_int)
450END
460SUB Plot_it(Time_div,Volts_div,Wave_form(*),Time_base)
470DIM X_axis$(80),Y_axis$(80)
480GINIT
490GRAPHICS ON
500RAD
510MOVE 35,10
520LDIR 0
530X_axis$="TIME/DIV = "&VAL$(Time_div)
540LABEL X_axis$
550MOVE 15,35
560LDIR PI/2

```



```
570Y_axis$="VOLTS/DIV = "&VAL$(Volts_div)
580LABEL Y_axis$
590VIEWPORT 20,110,20,90
600WINDOW 0,10*Time_div,-4*Volts_div,4*Volts_div
610AXES Time_div/5,Volts_div/5,0,0,1,1,1
620GRID Time_div,Volts_div
630Wave x=0
640MOVE Wave_x,Wave_form(BASE(Wav_form,1))
650FOR Wave_y=BASE(Wave_form,1)+1 TO SIZE(Wave_form,1)-1+BASE
(Wave_form,1)
660 Wave_x=Wave_x+Time_base
670 DRAW Wave_x,Wave_form(Wave_y)
680NEXT Wave_y
690IF Wave_x>10*Time_div THEN DISP "More samples taken than displayed"
700SUBEND
```

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6 Command Reference

Introduction	224
Commands by Functional Group	230
Commands vs. Measurement Functions	232

Introduction

The first part of this chapter discusses the multimeter's language. This includes core commands, command termination, parameters, query commands, lists of commands by functional group, and a table relating commands to measurement functions. The remainder of the chapter consists of detailed descriptions of each command (listed in alphabetical order, by command).

Before using this chapter, you should read about the multimeter functions you need to use in the preceding tutorial chapters ([Chapter 2](#), [Chapter 3](#), [Chapter 4](#), and [Chapter 5](#)). The tutorial chapters describe each multimeter function and identify which commands you need to use. You can then use this chapter to learn more about the individual commands.

The commands in this chapter are described using the following format:

Command header → **BEEP**

Command description → Controls the multimeter's beeper. When enabled, the beeper emits a 1 kHz beep if an error occurs.

Syntax statement → **Syntax** **BEEP** [*control*]

shows the command format and its parameters. parameters shown in brackets ([]) are optional (have default values). parameters shown without brackets have no default values and must be specified.

Parameter description → *control* The *control* parameter choices are:

<i>control</i> Parameter	Numeric Query Equiv.	Description
OFF	0	Disables the beeper
ON	1	Enables the beeper
ONCE	2	Beeps once, then returns to previous mode (either OFF or ON)

Power-on value → **Power-on *control*** = last programmed value.
Default *control* = ONCE.

Default value →

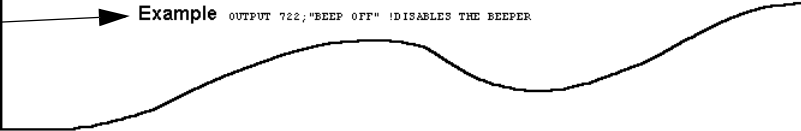
Remarks →

- The multimeter stores the *control* parameter in continuous memory (the parameter is not lost when power is removed).
- **Query Command.** The BEEP? query command returns the present beeper mode. Refer to "Query Commands" near the front of this chapter for more information.
- **Related Commands:** TONE

Remarks → contains special information about the command.

Examples → **Example** OUTPUT 722;"BEEP OFF" !DISABLES THE BEEPER.

show typical BASIC language programs or statements (multimeter at address 722). Program syntax is applicable to HP Series 200/300 Computers.



Language conventions

The multimeter communicates with a system controller over the GPIB bus.^[1] Each instrument connected to GPIB has a unique address. The examples used in this manual are intended for Hewlett-Packard Series 200 or 300 Computers using BASIC language. They assume an GPIB interface select code of 7 and a device address of 22 (factory address setting) resulting in a combined GPIB address of 722. We recommend you retain this address to simplify programming.

Command termination

The carriage return (*cr*), line feed (*lf*), semicolon (;), or EOI sent concurrent with the last character indicate the end of message (command terminator) to the multimeter. When you send a command from the system controller in the standard format (e.g., OUTPUT 722;"TEST"), the controller typically adds a *cr lf* to the end of the command. With its input buffer off (off is the power-on input buffer mode), the multimeter processes the *cr* immediately, but does not process the *lf* until the command completes execution. This means that, because of the *lf*, the bus is held and you cannot regain use of the controller until the multimeter is done executing the command (or the GPIB CLEAR command is executed which aborts execution of the command). You can prevent the bus from being held by suppressing the *cr lf* when sending commands or by enabling the input buffer (INBUF ON command). The following program line shows how to use the # and K image specifiers to suppress *cr lf* when sending a multimeter command.

```
OUTPUT 722 USING "#,K";"TEST;"
```

NOTE

The # and K image specifiers apply to HP Series 200/300 computers. Refer to your computer's operating manual for information on how your computer suppresses *cr lf*. The semicolon following the TEST command indicates the end of the command to the multimeter and must be present when you suppress *cr lf*.

[1] GPIB (General Purpose Interface Bus) is Keysight Technologies implementation of IEEE Standard 488-1978 and ANSI MC1.1.

Multiple commands

Multiple commands, separated by semicolons, may be sent in one command string. For example, the following command string contains three multimeter commands.

```
OUTPUT 722; "TRIG HOLD;DCV 3;NPLC 10"
```

Parameters

Numbers specified as command parameters can be either integer, floating-point, or exponential in format. parameters in floating-point format are rounded to the nearest integer if the command requires an integer. For example, "SUB 2.49" is rounded *down* to "SUB 2" and "SUB 2.5" is rounded *up* to "SUB 3".

Defaulting parameters

You can default a parameter by omitting it or replacing it with -1 (minus 1). For example, to specify 10 for the first parameter and default the second parameter send:

```
OUTPUT 722;"ACV 10"
```

or

```
OUTPUT 722;"ACV 10,-1"
```

From remote only, you can use two commas to indicate a default value. For example, to specify 10 for the first parameter and default the second parameter, send:

```
OUTPUT 722;"ACV 10,,"
```

To default the first parameter (which selects autorange in this example) and specify .01 for the second parameter, send:

```
OUTPUT 722; "ACV,,.01"
```

Query commands

A query command ends with a question mark and returns one or more responses to a particular question. For example, the ID? query command returns the response *Keysight 3458A*.

Standard query commands

The following standard query commands are documented individually in this chapter:

AUXERR?LINE?
 CALNUM?MCOUNT?
 ERR?OPT?
 ERRSTR?REV?
 ID?SSPARM?
 ISCALE?STB?
 TEMP?

Additional query commands

In addition to the standard query commands, you can create others by appending a question mark to any command that can be used to configure or program the multimeter. (Query commands of this type are not documented individually in this chapter. Instead, they are combined with the parent command. That is, the AZERO command page contains information on both AZERO and AZERO?.) As an example, the AZERO command enables or disables the autozero function. The possible autozero modes are OFF, ON, or ONCE. You can determine the present autozero mode by appending a question mark to the AZERO command as shown in the following program.

```
10 OUTPUT 722;"AZERO?"
20 ENTER 722;A$
30 PRINT A$
40 END
```

In the power-on state, the multimeter returns numeric responses to query commands. For example, the above program might return 1 which is the numeric query equivalent of the ON parameter. Numeric query equivalents are listed under each applicable command in this chapter.

For commands that have parameter choices (such as the AZERO command), the query version of the command returns the presently specified choice (or its numeric query equivalent). Many commands use actual values specified in

seconds, volts, ohms, etc, instead of parameter choices. For example, the APER command specifies integration time in seconds. The range of values for this command is 500 ns to 1 s. When you send the APER? query command, the multimeter responds with the actual value of integration time presently specified.

The QFORMAT (query format) command can be used to specify whether query responses will be numeric (as shown above), alpha, or alphanumeric. For example, the following program changes the query format to ALPHA. This causes the multimeter to return an alpha command header and an alpha response (whenever possible) as shown in the following program.

```
10 OUTPUT 722;"QFORMAT ALPHA"
20 OUTPUT 722;"AZERO?"
30 ENTER 722;A$
40 PRINT A$
50 END
```

Typical response: AZERO ON

In the ALPHA query format, commands that use actual values return an alpha command header and a numeric response. For example, a typical response to the APER? query command is:

```
APER 166.667E-03
```

Many query commands can return both alpha and numeric responses. For example, the NRDGS? query command returns two responses. The first response is numeric and indicates the number of readings per trigger event. The second response is alpha (assuming QFORMAT = ALPHA) and indicates the specified sample event. The following program executes the NRDGS? query command and prints the responses.

```
10 OUTPUT 722;"NRDGS?"
20 ENTER 722;A$,B$
30 PRINT A$,B$
40 END
```

Responses to query commands are always output over the GPIB in the ASCII output format regardless of the specified output format. Following the query response, the output format returns to that previously specified (SINT, DINT, SREAL, DREAL, or ASCII).

Commands by Functional Group

The following is a list of all commands recognized by the multimeter categorized by function (measurement functions, digitizing, A/D converter, etc.).

Measurement functions

ACDCI
ACDCV
ACI
ACV
DCI
DCV
DSAC
DSDC
FREQ
FUNC
OHM
OHMF
PER
SSAC
SSDC

Measurement related

ACBAND
ARANGE
AZERO
DELAY
FIXEDZ
FSOURCE
LFILTER
OCOMP
PRESET (DIG, FAST, or NORM)
RANGE or R
RATIO
SETACV
SSPARM?
TERM

Digitizing

DSAC
DSDC
LEVEL
LFILTER
SLOPE
NRDGS
PRESET (DIG and FAST)
SSAC
SSDC
SSPARM?
SSRC
SWEEP
TIMER

Triggering

EXTOUT
LEVEL
LFILTER
NRDGS
SLOPE
SSRC
SWEEP
TARM
TBUFF
TIMER
TRIG or T

Reading memory

MCOUNT?
MEM
MFORMAT
MSIZE
RMEM

Program memory

CALL
COMPRESS
CONT
DELSUB
PAUSE
SCRATCH
SUB
SUBEND

State memory

PURGE
RSTATE
SCRATCH
SSTATE

A/D converter

APER
LFREQ
LINE?
NPLC
RES

Status

CSB
RQS
SRQ
STB?

Input/Output

END
INBUF
ISCALE?
OFORMAT
QFORMAT

Errors

AUXERR?
EMASK
ERR?
ERRSTR?

Math

MATH
MMATH
RMATH
SMATH

Keyboard

DEFKEY
LOCK
MENU

Bus

ADDRESS
ID?
SRQ

System

BEEP
DEFEAT
EXTOUT
OPT?
PRESET (DIG, FAST, or NORM)
QFORMAT
RESET
TONE

Display

DISP
NDIG

Calibration/Test

ACAL
CAL
CAL?
CALNUM?
CALSTR
REV?
SCAL
SECURE
TEMP?
TEST

 GPIB commands

ABORT IO
CLEAR
LOCAL
LOCAL LOCKOUT
REMOTE
SPOLL
TRIGGER

Commands vs. Measurement Functions

Table 6-1 shows the multimeter commands that apply only to certain measurement functions. A bullet (●) indicates the command applies with no restrictions. A number (1 – 5) indicates the command applies with qualifications (see numbered footnotes below the table). A blank indicates the command is not applicable to the measurement function. The remaining multimeter commands not shown in Table 6-1 apply to all measurement functions with no restrictions.

Table 6-1 Commands vs. measurement functions

	DCV	DCI	OHM OHMF	ACV ACDCV (ANA)	ACV ACDCV (SYNC)	ACV ACDCV (RNDM)	ACI ACDCI	FREQ PER	DSAC DSDC	SSAC SSDC
ACBAND				●	●	●	●	●		
APER	●	●	●	●			●			
ARANGE ¹	●	●	●	●	●	●	●	●		
AZERO	●	●	●							
FIXEDZ	●		●							
FSOURCE								●		
ISCALE?	●	●	●	●	●	●	●	1	●	●
LEVEL	●				2			3	●	●
LFILTER	●				●			●	●	●
LFREQ	●	●	●	●			●			
(M) MATH ¹	●	●	●	●	●	●	●	●	●	4
MFORMAT	●	●	●	●	●	●	●	1	●	5
NPLC	●	●	●	●			●			
OCOMP			●							
OFORMAT	●	●	●	●	●	●	●	1	●	5
RATIO	●			●	●	●				

Table 6-1 Commands vs. measurement functions

	DCV	DCI	OHM OHMF	ACV ACDCV (ANA)	ACV ACDCV (SYNC)	ACV ACDCV (RNDM)	ACI ACDCI	FREQ PER	DSAC DSDC	SSAC SSDC
SETACV				●	●	●				
SLOPE	●				2			3	●	●
SSPARM?										●
SSRC					●					●
SWEEP	●	●	●	●			●		●	●
TIMER	●	●	●	●			●		●	

1 You should not use the SINT or DINT output/memory format for FREQ or PER measurements; when a realtime or post-process math operation is enabled (except STAT or PFAIL); or when autorange is enabled.

2 Level triggering is the default sync source event for synchronous ACV or ACDCV; however, the level trigger voltage and the slope are determined automatically and cannot be specified.

3 You cannot use the LEVEL trigger or sample event for FREQ or PER measurements. You can, however, specify the voltage level and slope that the level detection circuits use to measure frequency or period.

4 You cannot use MATH for sub-sampling; you can use MMATH for sub-sampling.

5 For sub-sampling, when using reading memory, the memory format must be SINT. When not using reading memory, the output format must be SINT.

ACAL

Autocal. Instructs the multimeter to perform one or all of its self calibrations.

Syntax

ACAL [*type*][*security_code*]

type

The *type* parameter choices are:

<i>type</i> parameter	Numeric query equiv.	Description
ALL	0	Performs the DCV, OHMS, and AC autocal
DCV	1	DC voltage gain and offset (see first Remark)
AC	2	ACV flatness, gain, and offset (see second Remark)
OHMS	4	OHMS gain and offset (see third Remark)

Power-on *type* = none.

Default *type* = ALL.

security_code

When autocal is secured, you must enter the correct security code to perform an autocal. When autocal is not secured, no security code is required. Refer to the **SECURE** command for more information on the security code and how to secure or unsecure autocal.

Remarks

- Since the DCV autocal applies to all measurement functions, you should perform it before performing the AC or OHMS autocal. When ACAL ALL is specified, the DCV autocal is performed prior to the other autocal.
- The multimeter should be in a thermally stable environment with its power turned on for at least 2 hours before performing any autocal. For maximum accuracy, you should perform ACAL ALL once every 24 hours or when the multimeter's temperature changes by $\pm 1^{\circ}\text{C}$ from when it was last externally calibrated or from the last autocal.

- The AC autocal performs specific enhancements for ACV or ACDCV (all measurement methods), ACI or ACDCI, DSAC, DSDC, SSAC, SSDC, FREQ, and PER measurements.
- The OHMS autocal performs specific enhancements for 2- or 4-wire ohms, DCI, and ACI measurements.
- Always disconnect any AC 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 continuous memory (they remain intact when power is removed). You do not necessarily need to perform autocal simply because power has been cycled.
- The time required to perform each autocal routine is:
 ALL:11 minutes
 DCV:1 minute
 AC:1 minute
 OHMS:10 minutes
- **Related commands:** CAL, SCAL, SECURE

Example

```
OUTPUT 722;"ACAL ALL,3458A" !RUNS ALL AUTOCALS USING
!FACTORY SECURITY CODE
```

ACBAND

AC band width. Specifies the frequency content (bandwidth) of the input signal for all AC or AC+DC measurements. Specifying the bandwidth allows the multimeter to configure for the fastest possible measurements.

Syntax

ACBAND [*low_frequency*][*high_frequency*]

low_frequency

Specifies the lowest expected frequency component of the input signal.

Power-on *low_frequency* = 20 Hz

Default *low_frequency* = 20 Hz

high_frequency

Specifies the highest expected frequency component of the input signal.

Power-on *high_frequency* = 20 MHz

Default *high_frequency* = 2 MHz

Remarks

- Refer to the “**Appendix A: Specifications**” on page 409 for accuracy and reading rate specifications based on the bandwidth of the input signal.
- For synchronous ACV or ACDCV (SETACV SYNC command), the bandwidth parameters are used by the multimeter to calculate time-out values and sampling parameters. When using level triggering (default mode), if the input signal is removed during a reading and does not return within the time limits, the measurement method changes to random so that the reading can be completed. (After the reading, the measurement method returns to SYNC.) For synchronous ACV or ACDCV, it is very important that the specified bandwidth corresponds to the frequency content of the signal being measured.
- For frequency or period measurements with autorange enabled, the bandwidth parameters are used to determine the amount of time needed for autoranging. For these measurements, it is very important that the specified bandwidth (especially *low_frequency*) corresponds to the frequency content of the signal being measured.
- If you are unsure of the frequency content of the input signal, default the ACBAND parameters.
- **Query command:** The ACBAND? query command returns two numbers separated by a comma. The first number is the currently specified *low_frequency*, the second number is the *high_frequency*. Refer to **Query commands** near the front of this chapter for more information.
- **Related commands:** ACDCI, ACDCV, ACI, ACV, FREQ, FUNC, PER, SETACV

Example

```
OUTPUT 722;"ACBAND 500,1000" !SPECIFIES THAT THE INPUT SIGNAL
                               !IS BETWEEN 500 - 1000 Hz
```


ACDCI, ACDCV, ACI, ACV

Refer to the **FUNC** command.

ADDRESS

Sets the multimeter's GPIB address (from the front panel only). The address is stored in continuous memory and is not lost when power is removed.

Syntax

ADDRESS *value*

value

The *value* parameter is an integer from 0 to 31.

Power-on *value* = previously stored address (factory setting = 22).

Default *value* = none; parameter required.

Remarks

- When you specify address 31, it doesn't actually change the multimeter's address but sets the multimeter to the Talk Only mode. In this mode, the multimeter outputs readings directly to an GPIB printer without a controller on the bus (you must use the ASCII output format). The multimeter's **TALK** annunciator illuminates when in Talk Only mode. You cannot specify address 31 with a controller on the bus. To remove the multimeter from Talk Only mode, press the **Reset** key or specify an address other than 31.
- The controller's address is typically 21. Do not use the controller's address for any other device on the GPIB bus.
- When the multimeter detects a CMOS RAM failure (auxiliary error bit 12). It sets the address to 22.
- **ADDRESS? query:** From the multimeter's front panel, you can read the present address using the **Address** key (shifted **Local** key).
- **Related commands:** ID?

APER

Aperture. Specifies the A/D converter integration time in seconds.

Syntax

APER [*aperture*]

aperture

Specifies the A/D converter's integration time and overrides any previously specified integration time or resolution. The valid range for *aperture* is 0 - 1 s in increments of 100 ns. (Specifying a value <500 ns selects minimum aperture which is 500 ns.)

Power-on *aperture* = is determined by the power-on value for NPLC which specifies an integration time of 166.667 ms for a 60 Hz power line frequency, or 200 ms for a power line frequency of 50 Hz or 400 Hz.

Default *aperture* = 500 ns.

Remarks

- Since the APER and NPLC commands both set the integration time, executing either will cancel the integration time previously established by the other. The RES command or the *%_resolution* parameter of a function or RANGE command can also be used to indirectly select an integration time. An interaction occurs between APER (or NPLC) when you specify resolution as follows:

If you send the APER (or NPLC) command *before* specifying resolution, the multimeter satisfies the command that specifies greater resolution (more integration time).

If you send the APER (or NPLC) command *after* specifying resolution, the multimeter uses the integration time specified by the APER (or NPLC) command, and any previously specified resolution is ignored.

- **Query command:** The APER? query command returns the currently specified integration time (in seconds) used by the A/D converter. The integration time may have been specified by the APER, NPLC, or RES command or by the *%_resolution* parameter of a function command or the RANGE command. Refer to **Query commands** near the front of this chapter for more information.
- **Related commands:** FUNC, NPLC, RANGE, RES

Example

```
OUTPUT 722; "APER 10E-6" !SETS APERTURE TO 10 MICROSECONDS
```

ARANGE

Autorange. Enables or disables the autorange function.

Syntax

ARANGE [*control*]

control

The *control* parameter choices are:

<i>control</i> parameter	Numeric query equiv.	Description
OFF	0	Disables autorange algorithm
ON	1	Enables autorange algorithm
ONCE	2	Causes the multimeter to autorange once, then disables autoranging

Power-on *control* = ON.

Default *control* = ON.

Remarks

- With autorange enabled, the multimeter samples the input signal before each reading and selects the appropriate range.
- Refer to the **FUNC** or **RANGE** command for a listing of the ranges for each measurement function.
- Autorange does not operate for direct- or sub-sampled measurements (DSAC, DSDC, SSAC, or SSDC command) or when using the TIMER sample event or the SWEEP command.
- **Query command:** The ARANGE? query command returns a response indicating the present autorange mode. Refer to **Query commands** near the front of this chapter for more information.

- **Related commands:** FUNC, RANGE

Example

```
OUTPUT 722;"ARANGE OFF" !DISABLES AUTORANGE
```

AUXERR?

Auxiliary error. When a hardware error is detected, the multimeter sets a bit in the auxiliary error register. The AUXERR? command returns a number representing the decimal-weighted sum of all set bits. The register is then cleared.

Syntax

```
AUXERR?
```

Auxiliary error conditions

The auxiliary error conditions and their weighted values are:

Weighted value	Bit number	Description
1	0	Slave processor not responding
2	1	DTACK failure
4	2	Slave processor self-test failure
8	3	Isolator test failure
16	4	A/D converter convergence failure
32	5	Calibration value out of range
64	6	GPIB chip failure
128	7	UART failure
256	8	Timer failure
512	9	Internal overload
1024	10	ROM checksum failure, low-order byte
2048	11	ROM checksum failure, high-order byte
4096	12	Nonvolatile RAM failure

Weighted value	Bit number	Description
8192	13	Option RAM failure
16384	14	Cal RAM write or protection failure

Remarks

- The auxiliary error register indicates hardware related errors. If one or more bits are set, the multimeter needs calibration or repair.
- The AUXERR? command returns a 0 if no error bits are set.
- If any bit in the auxiliary error register is set, the multimeter sets bit 0 (hardware error) in the error register. Reading the auxiliary error register does not clear bit 0 in the error register. You must read the error register (ERR? command) to clear it.
- Bits in the auxiliary error register cannot be masked to prevent them from setting bit 0 in the error register.
- **Related commands:** EMASK, ERR?, ERRSTR?, TEST

Example

```

10 OUTPUT 722;"AUXERR?" !READS THE AUXILIARY ERROR REGISTER
20 ENTER 722;A!ENTERS WEIGHTED SUM INTO VARIABLE A
30 PRINT A!PRINTS THE WEIGHTED SUM
40 END

```

As an example, assume the AUXERR? command returns the weighted sum 3072. This means that the errors with weighted values of 1024 (ROM checksum, low-order byte) and 2048 (ROM checksum, high-order byte) have occurred.

AZERO

Autozero. Enables or disables the autozero function. The autozero function applies only to DC voltage, DC current, and resistance measurements.

Syntax

AZERO [*control*]

control

The *control* parameter choices are:

<i>control</i> parameter	Numeric query equiv.	Description
OFF	0	Zero measurement is updated once, then only after a function, range, aperture, NPLC, or resolution change.
ON	1	Zero measurement is updated after every measurement.
ONCE	2	Zero measurement is updated once, then only after a function, range, aperture, NPLC, or resolution change.

Power-on *control* = ON

Default *control* = ON

Remarks

- When autozero is ON, the multimeter makes a zero measurement (measurement with the input disabled) following every reading and algebraically subtracts the zero measurement from the reading. This approximately doubles the time required per reading.
- Notice that the *control* parameters OFF and ONCE have the same effect. When autozero is OFF or ONCE, the multimeter makes one zero measurement and algebraically subtracts this from subsequent readings. After you execute AZERO OFF or AZERO ONCE, the multimeter takes the autozero measurement when the first trigger arm event occurs for all events except TARM EXT which causes an autozero measurement when the TARM EXT command is executed. The autozero measurement will be updated whenever the measurement function, range, or integration time is changed (this update will be made when the trigger arm event occurs or TARM EXT is executed).

- The display annunciator AZERO OFF illuminates when autozero is disabled.
- Autozero cannot be disabled for DC current measurements.
- For 2-wire ohms measurements with offset compensation enabled, the zero measurement and offset measurement are done simultaneously.
- Autozero should be on for 4-wire ohms measurements. If you must disable autozero, be sure to make all measurement connections before disabling autozero and ensure that the lead resistance will not change. If you disable autozero before making the 4-wire connections, or if you have a varying lead resistance with autozero disabled (such as when scanning), you will get inaccurate 4-wire ohms measurements.
- **Query command:** The AZERO? query command returns the present autozero mode. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** DCI, DCV, FUNC, OHM, OHMF

Example

OUTPUT 722; "AZERO OFF" !DISABLES AUTOZERO

BEEP

Controls the multimeter's beeper. When enabled, the beeper emits a 1 kHz beep if an error occurs.

Syntax

BEEP [*control*]

control

The *control* parameter choices are:

<i>control</i> parameter	Numeric query equiv.	Description
OFF	0	Disables the beeper
ON	1	Enables the beeper
ONCE	2	Beeps once, then returns to previous mode (either OFF or ON)

Power-on *control* = last programmed value.
 Default *control* = ONCE.

Remarks

- The multimeter stores the *control* parameter in continuous memory (the parameter is not lost when power is removed).
- **Query command:** The BEEP? query command returns the present beeper mode. Refer to **Query commands** near the front of this chapter for more information.
- **Related commands:** TONE

Example

```
OUTPUT 722;"BEEP OFF" !DISABLES THE BEEPER
```

CAL

This is a calibration command. Refer to the *3458A Calibration Manual* for details.

CALL

Call subprogram. Executes a previously stored subprogram.

Syntax

CALL [*name*]

name

Subprogram name. A subprogram name may contain up to 10 characters. The name can be alpha, alphanumeric, or an integer in the range of 0 to 127. Refer to the **SUB** command for details.

Power-on *name* = none.

Default *name* = 0.

Remarks

- Subprograms are created with the SUB command.

- The multimeter sets bit 0 in the status register after executing a stored subprogram.
- From the front panel, you can view all stored subprogram names by accessing the CALL command and pressing the up or down arrow key. Once you have found the correct subprogram, press the **Enter** key to execute the subprogram.
- **Related commands:** COMPRESS, CONT, DELSUB, PAUSE, SCRATCH, SUB, SUBEND

Examples

```
OUTPUT 722;"CALL DCCUR2" !EXECUTES SUBPROGRAM NAMED "DCCUR2"
```

CALNUM?

Calibration number query. Returns an integer indicating the number of times the multimeter has been calibrated.

Syntax

CALNUM?

Remarks

- The calibration number is incremented by 1 whenever the multimeter is calibrated. If autocal is secured, the calibration number is also incremented by 1 whenever an autocal is performed; if unsecured, autocal does not affect the calibration number.
- The calibration number is stored in cal-protected memory and is not lost when power is removed.
- The multimeter was calibrated before it left the factory. When you receive the multimeter, read the calibration number to determine its initial value.
- **Related commands:** CAL, CALSTR, SCAL

Example

```
10 OUTPUT 722;"CALNUM?" !READS CALIBRATION NUMBER
20 ENTER 722;A!ENTERS RESPONSE INTO COMPUTER
30 PRINT A!PRINTS RESPONSE
40 END
```

CALSTR

Calibration string (remote only). Stores a string in the multimeter's nonvolatile calibration RAM. Typical uses for this string include the multimeter's internal temperature at the time of calibration (**TEMP?** command), date of calibration, technician's name, and the scheduled date for the next calibration.

Syntax

CALSTR *string*[*security_code*]

string

This is the alpha/numeric message that will be appended to the calibration RAM. The *string* parameter must be enclosed in single or double quotes. The maximum string length is 75 characters (the quotes enclosing the string are not counted as characters).

security_code

When the calibration RAM is secured (SECURE command) you must include the *security_code* in order to write a message to the calibration RAM. (You can always read the string using the CALSTR? command regardless of the security mode). Refer to the **SECURE** command for information on securing and unsecuring the calibration RAM.

Remarks

- **Query command:** The CALSTR? query command returns the character string from the multimeter's calibration RAM. This is shown in the second example below.
- **Related commands:** CAL, CALNUM?, SCAL, SECURE

Examples

CALSTR

```
OUTPUT 722;"CALSTR 'CALIBRATED 04/02/1987'"
```

CALSTR?

```
10 DIM A$[80] !DIMENSION STRING VARIABLE
```

```
20 OUTPUT 722; "CALSTR?" !READ THE STRING
```

```
30 ENTER 722;A$ !ENTER STRING
```

```
40 PRINT A$ !PRINT STRING
50 END
```

COMPRESS

Compress subprogram. Removes the ASCII text of a specified subprogram previously stored in memory. This saves memory space but removes the subprogram from continuous memory (the subprogram will be destroyed when power is removed).

Syntax

COMPRESS *name*

name

Subprogram name. A subprogram name may contain up to 10 characters. The name can be alpha, alphanumeric, or an integer in the range of 0 to 127. Refer to the **SUB** command for details.

Power-on *name* = none.

Default *name* = none; parameter required.

Remarks

- To avoid memory fragmentation, compress each subprogram before downloading other subprograms.
- You cannot store the COMPRESS command as part of a subprogram.
- **Related commands:** CALL, CONT, DELSUB, PAUSE, SCRATCH, SUB, SUBEND

Example

The following program statement compresses subprogram TEST12 (previously downloaded).

```
OUTPUT 722;"COMPRESS TEST12"
```

CONT

Continue. Resumes execution of a subprogram that has been suspended by a PAUSE command.

Syntax

CONT

Remarks

- The GPIB Group Execute Trigger function may also be used to resume execution of a suspended subprogram.
- Only one subprogram will be preserved in a suspended state. If a subprogram is paused and another is run which also becomes paused, the first will be terminated and the second will remain suspended.
- **Related commands:** PAUSE, SUB, SUBEND

Example

```
OUTPUT 722;"CONT" !CONTINUE SUBPROGRAM EXECUTION
```

CSB

Clear status byte. Clears (sets to 0) all bits in the status register.

Syntax

CSB

Remarks

- If a condition that set a bit in the status register still exists, that bit will be set again immediately after the CSB command is executed.
- When you clear bit 6 (service requested), the multimeter sets the GPIB SRQ line false.
- **Related commands:** RQS, SPOLL (GPIB command), STB?

Example

```
OUTPUT 722;"CSB" !CLEARS THE STATUS REGISTER
```

DCI, DCV

Refer to the **FUNC** command.

DEFEAT

Enables or disables the multimeter's input protection algorithm (see CAUTION below) and some syntax and error checking algorithms. With these algorithms disabled, the multimeter can change to a new measurement configuration faster than it can with them enabled.

Syntax

DEFEAT [*mode*]

mode

The *mode* parameter choices are:

<i>mode</i> parameter	Numeric query equiv.	Description
OFF	0	Enables protection, syntax, and error algorithms
ON	1	Disables protection, syntax, and error algorithms

Power-on *mode* = OFF

Default *mode* = OFF.

Remarks

CAUTION

DEFEAT ON must only be used when you are certain that overload voltages on the Input terminals will not exceed ± 100 V peak on the 10 V range or below. (On the 100 V and 1000 V ranges, the multimeter can withstand voltages up to ± 1200 V peak regardless of whether DEFEAT is ON or OFF.) DEFEAT ON disables (defeats) the input switch sequencing that protects the multimeter's input circuitry from overload voltages. If input protection is disabled and an overload situation is detected on the 10 V range or below, the multimeter will enable input protection and internally tally the overload for instrument warranty considerations.

- Since DEFEAT ON disables certain syntax checking and error reporting algorithms, it should be used only after all system programming is complete and operational.
- **Query command:** The DEFEAT? query command returns the present DEFEAT mode. Refer to [Query commands](#) near the front of this chapter for more information.

Example

```
OUTPUT 722;"DEFEAT ON" !DISABLES PROTECTION, SYNTAX, & ERROR ALGORITHMS
```

DEFKEY

Define key. Allows you to assign one or more commands to a particular user-defined function key on the front panel (these keys are labeled **f0** - **f9**). After assigning one or more commands to a key, pressing that key displays the command(s) on the multimeter's display. Pressing the **Enter** key will then execute the command(s) in the order listed. The DEFKEY DEFAULT command erases the strings assigned to all user-defined keys.

Syntax

```
DEFKEY number,string
```

or

```
DEFKEY DEFAULT
```

number

The *number* parameter is an integer in the range 0 - 9 (or F0 - F9) that designates the particular function key.

Power-on *number* = none.

Default *number* = 0.

string

The *string* parameter is the command or list of commands to be assigned to the function key. (Link multiple commands with a semicolon.) The *string* parameter must be enclosed in single or double quotes. The maximum string length is 40 characters (the quotes enclosing the string are not counted as characters).

Power-on *string* = none.

Default *string* = none (clears any previous *string*).

DEFAULT

Erases the strings assigned to all user-defined keys.

Remarks

- Key definitions stored from the front panel can be edited from the front panel. Definitions stored from remote cannot be edited.
- You cannot embed quotes in the DEFKEY *string*. This means you cannot use the DISP command with a message in quotation marks as a *string* parameter. You can, however, use the DISP command and an unquoted message (refer to the **DISP** command for limitations on unquoted messages).
- **Query command:** The DEFKEY? query command returns the *string* parameter currently assigned to a particular function key (see example below). The string returned by the DEFKEY? query command is enclosed by double quotation marks, regardless of whether single or double marks were used when it was specified.
- **Related commands:** LOCK, MENU

Examples

DEFKEY

```
OUTPUT 722;"DEFKEY 1,'DCI 1;AZERO 0FF;NPLC 0'" !ASSIGNS COMMANDS TO F1
```

Clearing All DEFKEYs

```

OUTPUT 722;"DEFKEY DEFAULT" !CLEARS ALL DEFKEYS
DEFKEY?
10 OUTPUT 722;"DEFKEY? 1" !RETURNS DEFINITION FOR KEY 1
20 ENTER 722;A$ !ENTERS DEFINITION INTO A$ VARIABLE
30 PRINT A$!PRINTS DEFINITION
40 END

```

A typical response returned by the above program is: "DCI 1;AZERO OFF;NPLC 0."
If nothing is assigned to DEFKEY 1, the above program returns: "DEFKEY F1."

DELAY

The DELAY command allows you to specify a time interval that is inserted between the trigger event and the first sample event.

Syntax

DELAY [*time*]

time

Specifies the delay time in seconds. Delay time can range from 1E-7 (100 ns) to 6000 seconds in 10 ns increments for direct- or sub-sampling (DSAC, DSDC, SSAC, or SSDC) or 100 ns increments for all other measurement functions. Specifying 0 for the delay sets the delay to its minimum possible value.

Power-on *time* = automatic (determined by function, range, resolution and ACBAND setting).

Default *time* = automatic (determined by function, range, resolution and ACBAND setting).

Remarks

- The default delay changes automatically (unless you have specified an alternate value) whenever you change the measurement function (DCV, ACV, etc.), the range, the resolution, or the AC bandwidth setting (ACBAND command).
- **Query command:** The DELAY? query returns the present delay time in seconds. Refer to [Query commands](#) near the front of this chapter for more information.

- **Related commands:** NRDGS, SWEEP, TIMER, TRIG

Examples

OUTPUT 722;"DELAY 5" !INSERTS A 5 SECOND DELAY

OUTPUT 722;"DELAY -1" !RETURNS TO AUTOMATIC (DEFAULT) DELAY

DELSUB

Delete subprogram. Removes a single subprogram from memory.

Syntax

DELSUB *name*

name

Subprogram name. A subprogram name may contain up to 10 characters. The name can be alpha, alphanumeric, or an integer in the range of 0 to 127. Refer to the **SUB** command for details.

Power-on *name* = none.

Default *name* = none; parameter required.

Remarks

- When a subprogram is deleted, the memory used to store it is freed and may be used to store a new subprogram (see the **SUB** command).
- To delete all subprograms at once, use the SCRATCH command.
- **Related commands:** COMPRESS, SCRATCH, SUB

Example

OUTPUT 722;"DELSUB TEST12" !DELETES SUBPROGRAM TEST12

DIAGNOST

This is a service-related command. Refer to the *3458A Service Manual* for details

DISP

Display. Enables or disables the multimeter's display, and may also be used to send a message to the display or to clear the display.

Syntax

DISP [*control*] [,*message*]

control

The *control* parameter choices are:

<i>control</i> parameter	Numeric query equiv.	Description
OFF	0	Displays message if included (if no message, dashes are displayed); inactivates all annunciators except ERR; readings are no longer displayed and the display is not updated except to service front panel keystrokes and query commands.
ON	1	Normal (power-on mode) display operation
MSG	2	Displays message, annunciators activated
CLR	3	Clears the display

Power-on *control* = ON.

Default *control* = ON.

message

The *message* parameter is the message to be displayed. The message may contain spaces, numerals, lower or upper case letters, and any of the following characters:

! # \$ % & ' () ^ \ / @ ; : [] , . + - = * < > ? _

Remarks

- You must enclose a message in quotation marks only if it contains a space, comma, or semicolon. Either single or double marks (' or ") may be used: the beginning and ending marks must match.
- A message may contain up to 75 characters (quotes enclosing the message are not counted as characters).
- **Query command:** The DISP? query command returns the currently specified *control* parameter. Refer to **Query commands** near the front of this chapter for more information.
- **Related commands:** NDIG

Examples

The following command causes the multimeter to display the message TIME-OUT and to stop automatically updating the display.

```
OUTPUT 722;"DISP OFF,TIME-OUT" !MESSAGE = TIME-OUT
```

In the following command, the message must be enclosed in quotation marks because it contains a space.

```
OUTPUT 722;"DISP MSG,'TIME OUT'" !MESSAGE = TIME OUT
```

DSAC, DSDC

Direct-sampling. Configures the multimeter for direct-sampled measurements (digitizing). The DSAC function measures only the AC component of the input waveform. The DSDC function measures the combined AC and DC components. Otherwise, the two functions are identical. The DSAC and DSDC functions use the track/hold circuit (2 nanosecond aperture) and a wide bandwidth input path (12 MHz bandwidth).

Syntax

DSAC [*max._input*] [,*%-resolution*]

DSDC [*max._input*] [,*%-resolution*]

max._input

Selects the measurement range. (You cannot use autorange for direct-sampled measurements). To select a range, you specify *max._input* as the input signal's expected peak amplitude. The multimeter then selects the correct range. The following table shows the *max._input* parameters and the ranges they select.

<i>max._put</i> parameter	Full scale		
	Selects range	SINT format	DINT format
0 to .012	10 mV	12 mV	50 mV
>.012 to .120	100 mV	120 mV	500 mV
>.120 to 1.2	1 V	1.2 V	5.0 V
>1.2 to 12	10 V	12 V	50 V
>12 to 120	100 V	120 V	500 V
>120 to 1E3	1000 V	1050 V	1050 V

Power-on *max._input* = not applicable
 Default *max._input* = 10 V

%_resolution

Is ignored by the multimeter when used with the DSAC or DSDC command. This parameter is allowed in the command syntax to be consistent with the other function commands (FUNC, ACT, DCV, etc.).

Remarks

- You cannot use autorange for direct-sampled measurements: you must specify the range as the first parameter of the DSAC or DSDC command (*max._input* parameter).
- Notice that when using the DINT memory/output format the full scale values for direct-sampling are 500% (5 times) the ranges of 10 mV, 100 mV, 1 V, 10 V, and 100 V. This is particularly important to consider when specifying the percentage for level triggering. When specifying the level triggering voltage, use a percentage of the range. For example, assume the input signal has a peak value of 20 V and you are using the 10 V range. If you want to level trigger at 15 V, specify a level triggering percentage of 150% (LEVEL 150

command). (The slew rate of the multimeter's amplifiers may be exceeded when measuring a signal with a frequency >2 MHz and an amplitude >120% of range; signals <120% of range with frequencies up to 12 MHz do not cause slew rate errors.)

- The multimeter's triggering hierarchy (trigger arm event, trigger event, and sample event) applies to direct-sampling. This means that these events must occur in the proper order before direct-sampling begins. Refer to [Chapter 4](#) for more information on the triggering hierarchy. For direct-sampling, you can use either the TIMER sample event and the NRDGS n,TIMER command, or the SWEEP command (SWEEP is the simpler to program). The NRDGS and SWEEP commands are interchangeable, the multimeter uses whichever command was specified last. (When using the SWEEP command, the sample event is automatically set to TIMER.)
- For direct-sampling, you should use the SINT memory/output format when the peak value of the input signal is <120% of the specified range. Use the DINT memory/output format when the input signal is ≥120% of the range. (SINT and DINT are the formats used internally by the A/D converter; by using the correct memory/output format, no format conversions are necessary.)
- **Related commands:** DSDC, FUNC, LEVEL, LFILTER, SLOPE, NRDGS, PRESET FAST, PRESET DIG, SSAC, SSDC, SSPARM?, SWEEP, TARM, TIMER, TRIG

Example

The following program is an example of DC-coupled, direct-sampled digitizing. The SWEEP command specifies an interval of 30 μs and 200 samples. Level triggering is set for 250% of the 10 V range (250% of 10 V = 25 V). The samples are sent to reading memory in DINT format. The samples are then sent to the controller, converted, and printed. By deleting line 110, samples will be transferred directly to the controller instead of using reading memory. However, the controller and GPIB must be able to transfer samples at a rate of at least 134k-bytes/second or the multimeter will generate the TRIGGER TOO FAST error. Refer to [High-speed transfer across GPIB](#) in [Chapter 4](#) for more information.

```
10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 INTEGER Num_samples,I,J,K !CREATE INTEGER VARIABLES
30 Num_samples = 200 !200 SAMPLES
30 ASSIGN @Dvm TO 722 !DESIGNATE MULTIMETER ADDRESS
40 ASSIGN @Buffer TO BUFFER [4*Num_samples] !ASSIGN BUFFER I/O PATH NAME
45 !SAMPLES, (4-BYTES/SAMPLE * 200 SAMPLES = 800 BYTES)
50 ALLOCATE REAL Samp(1:Num_samples) !CREATE REAL ARRAY FOR SAMPLES
```

```

60 OUTPUT @Dvm;"PRESET FAST" !DINT FORMATS, TARM SYN, TRIG AUTO
70 OUTPUT @Dvm;"SWEEP 30E-6,200" !30  $\mu$ s INTERVAL, 200 SAMPLES
80 OUTPUT @Dvm;"DSDC 10" !DIRECT-SAMPLING, 10 V RANGE
90 OUTPUT @Dvm;"LEVEL 250, DC" !LEVEL TRIGGER AT 250% OF RANGE (25 V)
100 OUTPUT @Dvm;"TRIG LEVEL" !LEVEL TRIGGER EVENT
110 OUTPUT @Dvm;"MEM FIFO" !ENABLE READING MEMORY, FIFO MODE
120 TRANSFER @Dvm TO @Buffer;WAIT !TRANSFER SAMPLES TO CONTROLLER
130 OUTPUT @Dvm;"ISCALE?" !QUERY SCALE FACTOR FOR DINT FORMAT
140 ENTER @Dvm;S !ENTER SCALE FACTOR
150 FOR I=1 TO Num_samples
160 ENTER @Buffer USING "#,W,W";J,K !ENTER ONE 16-BIT 2'S COMPLEMENT
161 !WORD INTO EACH VARIABLE J AND K (# = STATEMENT TERMINATION NOT
165 !REQUIRED; W= ENTER DATA AS 16-BIT 2'S COMPLEMENT INTEGER)
170 Samp(I)=(J*65536.+K+65536.*(K<0)) !CONVERT TO REAL NUMBER
180 R=ABS(Samp(I)) !USE ABSOLUTE VALUE TO CHECK FOR OVLD
190 IF R>2147483647 THEN PRINT "OVLD" !IF OVERLOAD OCCURRED, PRINT
MESSAGE
200 Samp(I)=Samp(I)*S !APPLY SCALE FACTOR
210 Samp(I)=DROUND(Samp(I),8) !ROUND CONVERTED READING
220 PRINT Samp(I) !PRINT READINGS
230 NEXT I
240 END

```

EMASK

Error mask. Enables certain error condition(s) to set the error bit (bit 5) in the status register.

Syntax

EMASK [*value*]

value

You enable an error condition by specifying its decimal weight as the *value* parameter. To enable more than one error condition, specify the sum of the weights. The error conditions and their weights are:

Weighted value	Bit number	Error conditions
1	0	Hardware error (see AUXERR? for more information)
2	1	Calibration error
4	2	Trigger too fast error
8	3	Syntax error
16	4	Command not allowed from remote (ADDRESS command)
32	5	Undefined parameter received
64	6	Parameter out of range
128	7	Memory error
256	8	Destructive overload detected
512	9	Out of calibration
1024	10	Calibration required
2048	11	Settings conflict (memory improperly configured for sub-sampling)
4096	12	Math error (divide by 0, integer overflow, etc.)
8192	13	Subprogram error (calling a deleted sub, CONT with no PAUSE, SUBEND or PAUSE only allowed in sub, SCRATCH, DELSUB, CONT, not allowed in sub)
16384	14	System error

Power-on *value* = 32767 (all enabled).

Default *value* = 32767 (all enabled).

Remarks

- When an error occurs, it sets the corresponding bit in the *error register* regardless of whether or not it has been enabled by the EMASK command. Disabling an error bit prevents it from setting the error bit in the *status register* only, and thereby generating a service request.
- **Query command:** The EMASK? query command returns the weighted sum of all enabled error conditions (see example below).
- **Related commands:** AUXERR?, ERR?, ERRSTR?, RQS, STB?

Examples

```
OUTPUT 722;"EMASK 4" !ENABLES THE TRIGGER TOO FAST ERROR
OUTPUT 722;"EMASK 248" !ENABLES ERRORS 8, 16, 32, 64, AND 128
OUTPUT 722;"EMASK 0" !DISABLES ALL ERRORS
10 OUTPUT 722; "EMASK?" !RETURNS EMASK VALUE
20 ENTER 722;A !ENTER RESPONSE
30 PRINT A !PRINT VALUE
40 END
```

END

The END command enables or disables the GPIB End Or Identify (EOI) function.

Syntax

END [*control*]

control

The *control* parameter choices are:

<i>control</i> parameter	Numeric query equiv.	Description
OFF	0	EOI line never set true
ON	1	For multiple readings (SWEEP or NRDGS >1) the EOI line is set true with the last byte of the last reading sent. For single readings, EOI line set true with the last byte of each reading.
ALWAYS	2	EOI line set true when the last byte of each reading sent.

Power-on *control* = OFF.
Default *control* = ALWAYS.

Remarks

- Each reading output to the GPIB in ASCII format is normally followed by *cr,lf* (carriage return, line feed). The *cr lf* indicates the end of transmission to most

controllers. Readings output in any other format do not have the *cr lf* end of line sequence. When using the ASCII output format and multiple readings are recalled from reading memory using the RMEM command, the multimeter places a comma between readings. In this case, the *cr lf* occurs only once, following the last reading in the group being recalled. Commas are not used when readings are output directly to the bus (reading memory disabled), when readings are recalled using “implied read”, or when using any other output format.

- Check your computer manual for information on how your computer responds to the EOI line.
- If END ALWAYS is specified for the high-speed mode, the EOI mode automatically becomes ON while the readings are being taken. Following completion of the readings, the EOI mode returns to ALWAYS. Refer to [Increasing the Reading Rate](#) in [Chapter 4](#) for more information on the high-speed mode.
- **Query command:** The END? query command returns the present EOI mode. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** OFORMAT

Example

```
OUTPUT 722;"END ALWAYS" !ENABLES GPIB EOI
```

ERR?

Error query. When an error occurs, it sets a bit in the error register and illuminates the display's ERR annunciator. The ERR? command returns a number representing all set bits, clears the register, and shuts off the annunciator. The returned number is the weighted sum of all set bits.

Syntax

ERR?

Error Conditions

The error conditions and their weighted values are:

Weighted value	Bit number	Error conditions
1	0	Hardware error (see AUXERR? for more information)
2	1	Calibration error
4	2	Trigger too fast error
8	3	Syntax error
16	4	Command not allowed from remote (ADDRESS command)
32	5	Undefined parameter received
64	6	Parameter out of range
128	7	Memory error
256	8	Destructive overload detected
512	9	Out of calibration
1024	10	Calibration required
2048	11	Settings conflict (memory improperly configured for sub-sampling)
4096	12	Math error (divide by 0, integer overflow, etc.)
8192	13	Subprogram error (calling a deleted sub, CONT with no PAUSE, SUBEND, or PAUSE only allowed in sub, SCRATCH, DELSUB, CONT, not allowed in sub)
16384	14	System error

Remarks

- The ERR? command returns a 0 if no error bits are set.
- If bit 0 is set (weight = 1), refer to the auxiliary error register ([AUXERR?](#) command) for more information.
- Executing the ERR? command clears the status register's error bit (bit 5).
- **Related commands:** AUXERR?, EMASK, ERRSTR?

Example

```
10 OUTPUT 722;"ERR?" !READS & CLEARS ERROR REGISTER
20 ENTER 722;A !ENTERS WEIGHTED SUM INTO VARIABLE A
```

```

30 PRINT A!PRINTS RESPONSE
40 END

```

ERRSTR?

Error string query. The ERRSTR? command reads the least significant set bit in either the error register or the auxiliary error register and then clears the bit. The ERRSTR? command returns two responses separated by a comma. The first response is an error number (100 Series = error register; 200 Series = auxiliary error register) and the second response is a message (string) explaining the error.

Syntax

ERRSTR?

Remarks

- The maximum string length returned by ERRSTR? is 255 characters.
- The ERRSTR? command reads and clears only the least significant set bit in a register. If more than one bit is set in a register, you must execute ERRSTR? repetitively to read and clear each set bit. After all set bits have been read and cleared (or if there were no set bits in either register), the ERRSTR? command returns 0, "NO ERROR". When the auxiliary and error registers are cleared, the error bit in the status register (bit 5) will also be cleared.
- When bit 0 in the error register is set, it means that one or more bits in the auxiliary error register are set. In this case, the ERRSTR? command reads and clears each set bit in the auxiliary error register first. When all auxiliary errors have been read, bit 0 in the error register is cleared and the ERRSTR? command can then be used to read any remaining errors in the error register.
- **Related commands:** AUXERR?, EMASK, ERR?, QFORMAT

Example

```

10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM A$(200) !DIMENSION STRING VARIABLE
30 OUTPUT 722;"ERRSTR?"!READS ERROR MESSAGE
40 ENTER 722; A,A$ !ENTERS NUMERIC INTO A, STRING INTO A$
50 PRINT A,A$ !PRINTS RESPONSES

```

```

60 IF A>0 THEN GOTO 30 !LOOPS FOR EACH ERROR
70 END

```

EXTOUT

External output. Specifies the event that will generate a signal on the rear panel Ext Out connector (EXTOUT signal). This command also specifies the polarity of the EXTOUT signal.

Syntax

EXTOUT [*event*][*,polarity*]

event

The *event* choices are:

<i>event</i> parameter	Numeric query equiv.	Description
OFF	0	None; EXTOUT is disabled
ICOMP	1	Input complete (1 μ s pulse after A/D converter has integrated each reading or, for direct- or sub-sampling, after the track and hold has acquired the input signal)
ONCE	2	Outputs a 1 μ s pulse upon execution of the EXTOUT ONCE command; the event then becomes OFF
APER	3	Aperture waveform (a level indicating when the A/D converter is making a measurement)
BCOMP	4	Burst complete (1 μ s pulse following a group of readings)
SRQ	5	Status event occurred (1 μ s pulse whenever a status register event occurs that has been enabled to assert the GPIB SRQ). (See second Remark below.)
RCOMP	6	Reading complete (1 μ s pulse after each reading)

Power-on *event* = ICOMP.
Default *event* = ICOMP.

polarity

Specifies the polarity of the EXTOUT signal. The choices are:

<i>polarity parameter</i>	Numeric query equiv.	Description
NEG	0	Generates a low-going TTL signal
POS	1	Generates a high-going TTL signal

Power-on *polarity* = NEG.

Default *polarity* = NEG.

Remarks

- All events except APER generate a 1 μ s pulse on the EXTOUT connector. If APER is selected, the A/D's aperture waveform is output directly. The leading edge of the EXTOUT signal is the response to the event. Refer to [The EXTOUT Signal](#) in [Chapter 4](#) for a detailed description of the above events.
- When a status event sets the SRQ bit in the status register, that bit remains set until cleared (CSB command, for example). When specified, the EXTOUT SRQ pulse occurs whenever any status event occurs that has been enabled to assert SRQ (RQS command). The EXTOUT SRQ pulse does not necessarily occur whenever the SRQ bit is set; it occurs whenever an enabled status event occurs.
- **Query command:** The EXTOUT? query command returns two responses separated by a comma. The first response indicates the currently specified EXTOUT event. The second response indicates the *polarity*. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** NRDGS, SRQ, STB?, SWEEP, TBUF

Example

```
OUTPUT 722;"EXTOUT APER" !SETS EXTOUT EVENT TO APERTURE WAVEFORM
```

FIXEDZ

The FIXEDZ command enables or disables the fixed input resistance function for DC voltage measurements. When enabled, the multimeter maintains its input resistance at 10 megohms for all ranges. This prevents a change in input resistance (caused by a range change) from affecting the DC voltage measurements.

Syntax

FIXEDZ [*control*]

control

The *control* parameter choices are:

<i>control</i> parameters	Numeric query equiv.	Description	Input resistances	
			DCV .1 V, 1 V, 10 V, and 1000 V ranges	DCV 100 V ranges
OFF	0	FIXEDZ disabled	>10 G Ω	10 M Ω
ON	1	FIXEDZ enabled	10 M Ω	10 M Ω

Power-on *control* = OFF.

Default *control* = ON.

Remarks

- FIXEDZ remains enabled when you change from DC voltage measurements to 2-wire or 4-wire ohms measurements. Resistance measurements made with FIXEDZ enabled will be in error because the multimeter's input resistance represents a 10 M Ω resistance in parallel with the input terminals.
- FIXEDZ is temporarily disabled when you change from DC voltage measurements to AC voltage, AC+DC voltage, any type of current, frequency, or period measurements. For example, if FIXEDZ is enabled and you change from DC voltage measurements to AC voltage measurements, FIXEDZ becomes disabled. When you return to DC voltage measurements, however, FIXEDZ is once again enabled.

- **Query command:** The FIXEDZ? query command returns the present fixed input resistance mode. Refer to **Query commands** near the front of this chapter for more information.
- **Related commands:** DCV, FUNC, OHM, OHMF,

Example

OUTPUT 722; "FIXEDZ ON" !ENABLES FIXED IMPEDANCE

FREQ

Frequency. Instructs the multimeter to measure the frequency of the input signal. You must specify whether the input signal is AC voltage, AC+DC voltage, AC current, or AC+DC current using the FSOURCE command.

Syntax

FREQ [*max._input*][, *%_resolution*]

max._input

Selects a fixed range or the autorange mode. The ranges correspond to the type of input signal specified in the FSOURCE command. That is, if ACV is the specified input signal, the *max._input* parameter specifies an AC voltage measurement range. To select a fixed range, you specify *max._input* as the absolute value (no negative numbers) of the expected peak value of the input signal. The multimeter then selects the proper range. Refer to the **FUNC** or **RANGE** command for tables showing the ranges available for each type of input signal.

To select the autorange mode, specify AUTO for *max._input* or default the parameter. In the autorange mode, the multimeter samples the input signal before each frequency reading and selects the proper range.

Power-on *max._input* = not applicable.

Default *max._input* = AUTO.

%_resolution

The *%_resolution* parameter specifies the digits of resolution and the gate time as shown below (*%_resolution* also affects the reading rate, refer to the **"Appendix A: Specifications"** on page 409 for more information).

%_resolution parameter	Selects gate time	Digits of resolution
.00001	1 s	7
.0001	100 ms	7
.001	10 ms	6
.01	1 ms	5
.1	100 μ s	4

Power-on %_resolution = not applicable.

Default %_resolution = .00001

Remarks

- The reading rate is the longer of 1 period of the input signal, the gate time, or the default reading timeout of 1.2 seconds.
- Frequency (and period) measurements are made using the level detection circuitry to determine when the input signal crosses a particular voltage on its positive or negative slope. (This is why you cannot use the LEVEL trigger or sample event or the LINE trigger event when making frequency or period measurements.) The power-on or default level triggering values select zero volts, positive slope. You can control the level triggering voltage and coupling using the LEVEL command. You can specify either the positive or negative slope using the SLOPE command.
- The leftmost digit which is a half digit for most measurement functions, is a full digit (0 - 9) for frequency measurements.
- Readings made with autorange enabled take longer because the input signal is sampled (to determine the proper range) between frequency readings.
- For frequency (and period) measurements, an overload indication means the voltage or current amplitude is too great for the specified measurement range. It does not mean the applied frequency (or period) is too great to be measured.
- **Related commands:** ACBAND, FSOURCE, FUNC, LFILTER, PER, RES

Example

```
10 OUTPUT 722;"FSOURCE ACI" !SELECTS AC CURRENT AS INPUT SOURCE
20 OUTPUT 722;"FREQ .01,.001" !SELECTS FREQUENCY MEASUREMENTS, 10 mA
25 !RANGE, 10 ms GATE TIME, 5 DIGITS RES.
30 END
```

FSOURCE

Frequency source. Specifies the type of signal to be used as the input signal for frequency or period measurements.

Syntax

FSOURCE [*source*]

source

The *source* parameter choices are:

<i>source</i> parameter	Numeric query equiv.	Description (measurement capabilities)
ACV	2	AC voltage (FREQ 1 Hz - 10 MHz; PER 100 ns - 1 s)
ACDCV	3	AC+DC voltage (FREQ 1 Hz - 10 MHz; PER 100 ns - 1 s)
ACI	7	AC current (FREQ 1 Hz - 100 kHz; PER 10 μ s - 1 s)
ACDCI	8	AC+DC current (FREQ 1 Hz - 100 kHz; PER 10 μ s - 1 s)

Power-on *source* = ACV.

Default *source* = ACV.

Remarks

- **Query command:** The FSOURCE? query command returns the present frequency source. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** FREQ, FUNC, PER

Example

```
10 OUTPUT 722;"FSOURCE ACDCI" !SELECTS ACDCI AS THE INPUT SOURCE
20 OUTPUT 722;"FREQ .1,.9=01" !SELECTS FREQUENCY, 100 mA RANGE, 1 ms
25 !GATE TIME, 4 DIGITS OF RESOLUTION
30 END
```

FUNC

Function. Selects the type of measurement (AC voltage, DC current. etc.). It also allows you to specify the measurement range and resolution. (The FUNC header is optional and may be omitted.)

Syntax

```
FUNC [function][,max._input][,%_resolution]
```

or

```
[FUNC] function[,max._input][,%_resolution]
```

function

The *function* parameter designates the type of measurement. The parameter choices are:

<i>function</i> parameter	Numeric query equiv.	Description
DCV	1	Selects DC voltage measurements
ACV	2	Selects AC voltage measurements (the mode is set by the SETACV command)
ACDCV	3	Selects AC+DC voltage measurements (the mode is set by the SETACV command)
OHM	4	Selects 2-wire ohms measurements
OHMF	5	Selects 4-wire ohms measurements
DCI	6	Selects DC current measurements
ACI	7	Selects AC current measurements

<i>function parameter</i>	<i>Numeric query equiv.</i>	<i>Description</i>
ACDCI	8	Selects AC+DC current measurements
FREQ ^[a]	9	Selects frequency measurements
PER ^[a]	10	Selects period measurements
DSAC ^[a]	11	Direct sampling, AC coupled
DSDC ^[a]	12	Direct sampling, DC coupled
SSAC ^[a]	13	Sub-sampling, AC coupled
SSDC ^[a]	14	Sub-sampling, DC coupled

[a] These functions require additional explanation and are documented individually in this chapter. Refer to the corresponding **DSAC**, **DSDC**, **FREQ**, **PER**, or **SSAC**, **SSDC** command for details.

Power-on *function* = DCV.

Default *function* = DCV.

max._input

Selects a fixed range or the autorange mode. To select a fixed range, you specify *max._input* as the absolute value (no negative numbers) of the input signal's maximum expected amplitude (or the maximum resistance for ohms measurements). The multimeter then selects the correct range.

To select autorange, specify AUTO for *max._input* or default the parameter. In the autorange mode, the multimeter samples the input signal before each reading and selects the appropriate range.

- The following tables show the *max._input* parameters and the ranges they select for each measurement function.

For DCV:

<i>max_input parameter</i>	Selects range	Full scale
-1 or AUTO	Autorange	
0 to .12	100 mV	120 mV
>.12 to 1.2	1 V	1.2 V
>1.2 to 12	10 V	12 V
>12 to 120	100 V	120 V
>120 to 1E3	1000 V	1050 V

For ACV or ACDCV:

<i>max_input parameter</i>	Selects range	Full scale
-1 or AUTO	Autorange	
0 to .012	10 mV	12 mV
>.012 to .12	100 mV	120 mV
>.12 to 1.2	1 V	1.2 V
>1.2 to 12	10 V	12 V
>12 to 120	100 V	120 V
>120 to 1E3	1000 V	1050 V

For OHM or OHMF:

<i>max_input parameter</i>	Selects range	Full scale
-1 or AUTO	Autorange	
0 to 12	10 Ω	12 Ω
>12 to 120	100 Ω	120 k Ω
>120 to 1.2E3	1 k Ω	1.2 k Ω
>1.2E3 to 1.2E4	10 k Ω	12 k Ω
>1.2E4 1.2E5	100 k Ω	120 k Ω
>1.2E5 to 1.2E6	1 M Ω	1.20 M Ω
>1.2E6 to 1.2E7	10 M Ω	12 M Ω
>1.2E7 1.2E8	100 M Ω	120 M Ω
>1.2E8 1.2E9	1 G Ω	1.2 G Ω

For DCI:

<i>max_input parameter</i>	Selects range	Full scale
-1 or AUTO	Autorange	
0 to .12E-6	.1 μ A	.12 μ A
>.12E-6 to 1.2E-6	1 μ A	1.2 μ A
>1.2E-6 to 12E-6	10 μ A	12 μ A
>12E-6 to 120E-6	100 μ A	120 μ A
>120E-6 to 1.2E-3	1 mA	1.2 mA
>1.2E-3 to 12E-3	10 mA	12 mA
>12E-3 to 120E-3	100 mA	120 mA
>120E-3 to 1.2	1 A	1.05 A

For ACI or ACDCl:

<i>max._input</i> parameter	Selects range	Full scale
-1 or AUTO	Autorange	
0 to .120E-6	100 μ A	120 μ A
>120E-6 to 1.2E-3	1 mA	1.2 mA
>1.2E-3 to 12E-3	10 mA	12 mA
>12E-3 to 120E-3	100 mA	120 mA
>120E-3 to 1.2	1 A	1.05 A

For SSAC or SSDC:

<i>max._input</i> parameter	Selects range	Full scale
0 to .012	10 mV	12 mV
>.012 to .120	100 mV	120 mV
>.120 to 1.2	1 V	1.2 V
>1.2 to 12	10 V	12 V
>12 to 120	100 V	120 V
>120 to 1E3	1000 V	1050 V

For DSAC or DSDC:

<i>max._input</i> parameter	Full scale		
	Selects range	SINT format	DINT format
0 to .012	10 mV	12 mV	50 mV
>.012 to .120	100 mV	120 mV	500 mV
>.120 to 1.2	1 V	1.2 V	5.0 V
>1.2 to 12	10 V	12 V	50 V
>12 to 120	100 V	120 V	500 V
>120 to 1E3	1000 V	1050 V	1050 V

Power-on *max._input* = AUTO.Default *max._input* = AUTO.**%_resolution**

For most measurement functions, you specify the *%_resolution* as a percentage of the *max._input* parameter. (Refer to the **FREQ** and **PER** commands for tables showing how *%_resolution* affects frequency and period measurements; *%_resolution* is ignored when the *function* parameter is DSAC, DSDC, SSAC, or SSDC.)

For all functions except FREQ, PER, DSAC, DSDC, SSAC, and SSDC, the multimeter multiplies *%_resolution* times *max._input* to determine the measurement's resolution. For example, suppose you are measuring DC voltage, your maximum expected input is 10 V, and you want 1 mV of resolution. To determine *%_resolution*, use the equation:

$$\%\_resolution = (\text{actual resolution}/\text{maximum input}) \times 100$$

For this example, the equation evaluates to:

$$\%\_resolution = (.001/10) \times 100 = .0001 \times 100 = .01$$

NOTE

When using autorange, the multimeter multiplies the *%_resolution* parameter times the full scale reading of the selected range. The result is the minimum resolution. The multimeter always gives you at least the minimum resolution and, in many cases, gives you additional digits of resolution.

Power-on *%_resolution* = none. At power-on, the resolution is determined by the NPLC command which produces 8½ digits. (The power-on value for NDIG masks 1 display digit causing the multimeter to display only 7½ digits. You can use the NDIG 8 command to display all 8½ digits; refer to the **NDIG** command for details.)

Default % resolution:

For frequency or period measurements, the default *%_resolution* is .00001 which selects a gate time of 1 s and 7 digits of resolution.

For sampled ACV or ACDCV, the default *%_resolution* is 0.01% for SETACV SYNC, or 0.4% for SETACV RNDM.

For all other measurement functions, the default resolution is determined by the present integration time.

Remarks

- **Query command:** The FUNC? query command returns two responses separated by a comma. The first response is the present measurement function. The second response is the present measurement range (this is the actual range, not necessarily the value specified for *max_input*). The FUNC? query command does not indicate the autorange mode. Use the ARANGE? query to determine the autorange mode. Refer to **Query commands** near the front of this chapter for more information.
- **Related commands:** ACDCI, ACDCV, ACI, ACV, APER, DCI, DCV, DSAC, DSDC, FREQ, OHM, OHMF, PER, RATIO, NPLC, RES, SETACV, SSAC, SSDC

Examples

In the following program, line 10 allows *%_resolution* in line 20 to control the resolution. The resolution specified by line 20 is $6\text{ V} \times .0000167 = 100\text{ }\mu\text{V}$.

```
10 OUTPUT 722;"NPLC 0" !SETS PLCS TO MINIMUM
20 OUTPUT 722;"FUNC DCV,6,.00167" !SELECTS DC VOLTS, 6 V MAX,
30 END !100 μV RESOLUTION
```

In the following program, line 10 sets the number of PLCs to 1000. This corresponds to maximum resolution (7.5 digits) and prevents *%_resolution* in line 20 from affecting the measurement. The requested resolution from line 20 is $10\text{ }\mu\Omega$. However, because of line 10, the actual resolution is $100\text{ }\mu\Omega$.

```
10 OUTPUT 722;"NPLC 1000" !SETS PLCS TO MAXIMUM
20 OUTPUT 722;"FUNC OHM,1E3,.001" !SELECTS 2-WIRE OHMS,
30 END !1 kΩ MAX, 10 mΩ RESOLUTION
```

ID?

Identity query. The multimeter responds to the ID? command by sending the string "Keysight 3458A". This feature allows the GPIB controller to locate the multimeter by its address.

Syntax

ID?

Remarks

- **Related commands:** ADDRESS, QFORMAT

Example

```
10 OUTPUT 722;"ID?" !RETURNS RESPONSE
20 ENTER 722;A$ !ENTERS RESPONSE INTO THE COMPUTER'S A$ VARIABLE
30 PRINT A$ !PRINTS RESPONSE
40 END
```

INBUF

Input buffer. Enables or disables the multimeter's input buffer. When enabled, the input buffer temporarily stores the commands it receives over the GPIB bus. This releases the bus immediately after a command is received, allowing the controller to perform other tasks while the multimeter executes the stored command.

Syntax

INBUF [*control*]

control

The *control* parameter choices are:

<i>control</i> parameter	Numeric query equiv.	Description
OFF	0	Disables the input buffer; commands are accepted only when the multimeter is not busy
ON	1	Enables the input buffer; commands are stored, releasing the bus immediately

Power-on *control* = OFF.
Default *control* = ON.

Remarks

- Turning the input buffer OFF causes a minor degradation in speed performance, but is useful for synchronizing bus activity. With the input buffer OFF, the multimeter accepts only one command at a time and does not release the bus until it has finished executing that command. This ensures that subsequent commands sent to other bus devices cannot be executed until the multimeter has finished executing its command(s).
- Turning the input buffer ON causes the multimeter to buffer (store) incoming messages and release the GPIB bus as soon as message transmission is complete. This allows the controller to communicate with other bus devices while the multimeter executes its command(s). However, synchronization with other bus devices may be lost if they execute their instructions before the multimeter finishes its instructions. In this case, the ready bit in the status

register may be monitored (using a serial poll) to determine when the multimeter is finished.

- A series of commands longer than 255 characters fills the input buffer and causes the multimeter to halt bus activity while it executes the first commands received. The remainder of the message is input when room becomes available in the buffer.
- **Query command:** The INBUF? query command returns the present input buffer mode. Refer to [Query commands](#) near the front of this chapter for more information.

Example

The following program enables the input buffer prior to running all of the autocalibration routines. This prevents the bus from being held during the autocal which takes over 11 minutes to complete.

```
10 OUTPUT 722;"INBUF ON" !ENABLE INPUT BUFFER
20 OUTPUT 722;"ACAL ALL" !AUTOCAL (TAKES >11 MINUTES)
30 END
```

ISCALE?

Integer scale query. Returns the scale factor for readings output in the SINT or DINT formats.

Syntax

ISCALE?

Remarks

- The scale factor is always 1 for the ASCII, SREAL, and DREAL output formats.
- Readings output in the SINT or DINT formats (see the [OFORMAT](#) command) are first compressed by the multimeter so they may be expressed as integers. Multiplying the readings by the value returned by ISCALE? will restore them to their actual values. The scale factor is determined by the configuration of the multimeter when ISCALE? is executed. This includes the measurement function, range, and integration time. Therefore, the multimeter's configuration must be the same when the scale factor is retrieved as it was when the readings were taken. You can retrieve the scale factor after the

multimeter is configured but before readings are triggered or immediately after the readings made.

- You should not use the SINT or DINT output or memory format for frequency or period measurements when a real-time or post-process math function is enabled (except STAT or PFAIL) or when autorange is enabled.
- **Related commands:** OFORMAT, SSAC, SSDC

Examples

SINT example

The following program outputs 10 readings in SINT format, retrieves the scale factor, and multiplies the scale factor times each reading.

```

10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 INTEGER Int_rdgs (1:10) BUFFER !CREATE INTEGER BUFFER ARRAY
30 REAL Rdgs(1:10) !CREATE REAL ARRAY
40 Num_readings=10! NUMBER OF READINGS = 10
50 ASSIGN @Dvm TO 722 !ASSIGN MULTIMETER ADDRESS
60 ASSIGN @Int_rdgs TO BUFFER Int_rdgs(*) !ASSIGN BUFFER I/O PATH NAME
70 OUTPUT @Dvm;"PRESET NORM;OFORMAT SINT;NPLC 0;NRDGS ";Num_readings
75 !TARM AUTO, TRIG SYN, SINT OUTPUT FORMAT, MIN. INTEGRATION TIME
80 TRANSFER @Dvm TO @Int_rdgs;WAIT !SYN EVENT, TRANSFER READINGS INTO
81 !INTEGER ARRAY; SINCE THE COMPUTER'S INTEGER FORMAT IS THE SAME AS
85 !SINT,NO DATA CONVERSION IS NECESSARY HERE (INTEGER ARRAY REQUIRED)
90 OUTPUT @Dvm;"ISCALE?" !QUERY SCALE FACTOR FOR SINT FORMAT
100 ENTER @Dvm;S !ENTER SCALE FACTOR
110 FOR I=1 TO Num_readings
120 Rdgs(I)=Int_rdgs(I) !CONVERT EACH INTEGER READING TO REAL
125 !FORMAT (NECESSARY TO PREVENT POSSIBLE INTEGER OVERFLOW ON NEXT
LINE)
130 R=ABS(Rdgs(I)) !USE ABSOLUTE VALUE TO CHECK FOR OVLD
140 IF R>=32767 THEN PRINT "OVLD" !IF OVLD, PRINT OVERLOAD MESSAGE
150 Rdgs(I)=Rdgs(I)*S !MULTIPLY READING TIMES SCALE FACTOR
160 Rdgs(I)=DROUND(Rdgs(I),4) !ROUND TO 4 DIGITS
170 NEXT I
180 END

```

DINT example

The following program is similar to the preceding program except that it takes 50 readings and transfers them to the computer using the DINT format.

```

10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 INTEGER Num_readings,I,J,K !DECLARE VARIABLES
30 Num_readings=50 !NUMBER OF READINGS = 50
40 ALLOCATE REAL Rdgs(1:Num_readings) !CREATE ARRAY FOR READINGS
50 ASSIGN @Dvm TO 722 !ASSIGN MULTIMETER ADDRESS
60 ASSIGN @Buffer TO BUFFER[4*Num_readings] !ASSIGN BUFFER I/O PATH NAME
70 OUTPUT @Dvm;"PRESET NORM;RANGE 10;OFORMAT DINT;NRDGS ";Num_readings
75 !TARM AUTO, TRIG SYN, DCV 10 V RANGE, DINT OUTPUT FORMAT, NRDGS
50,AUTO
80 TRANSFER @Dvm TO @Buffer;WAIT !SYN EVENT,TRANSFER READINGS
90 OUTPUT @Dvm; "ISCALE?" !QUERY SCALE FOR DINT
100 ENTER @Dvm;S !ENTER SCALE FACTOR
110 FOR I=1 TO Num_readings
120 ENTER @Buffer USING "#,W,W";J,K !ENTER ONE 16-BIT 2'S COMPLEMENT
121 !WORD INTO EACH VARIABLE J AND K (# = STATEMENT TERMINATION NOT
125 !REQUIRED; W= ENTER DATA AS 16-BIT 2'S COMPLEMENT INTEGER)
130 Rdgs(I)=(J*65536.+K+65536.*(K<0)) !CONVERT TO REAL NUMBER
140 R=ABS(Rdgs(I))!USE ABSOLUTE VALUE TO CHECK FOR OVLD
150 IF R>2147483647 THEN PRINT "OVLD" !IF OVERLOAD OCCURRED, PRINT
MESSAGE
160 Rdgs(I)=Rdgs(I)*S !APPLY SCALE FACTOR
170 Rdgs(I)=DROUND(Rdgs(I),8) !ROUND CONVERTED READING
180 PRINT Rdgs(I) !PRINT READINGS
190 NEXT I
200 END

```

LEVEL

The LEVEL command specifies the level triggering voltage (as a percentage of the present range) and the coupling (AC or DC) for level triggering. A level trigger event occurs when the input signal reaches the specified voltage on its positive-going or negative-going slope as specified by the SLOPE command.

Syntax

LEVEL [*percentage*][,*coupling*]

percentage

Specifies the percentage of the present range for level triggering. The valid range for this parameter is -500% to +500% in 5% steps for direct- or sub-sampling or -120% to 120% in 1% steps for DC voltage (refer to [Chapter 5](#) for details).

Power-on *percentage* = 0% (0 V).

Default *percentage* = 0% (0 V).

The full scale values for direct-sampling are 500% (5 times) the ranges of 10 mV, 100 mV, 1 V, 10 V, and 100 V. When specifying the level triggering percentage, remember to use a percentage of the range. For example, assume the input signal has a peak value of 20 V and you are using the 10 V range. If you want to level trigger at 15 V, you would specify a level triggering percentage of 150% (LEVEL 150 command).

coupling

The coupling parameter selects the coupling of the signal to the level-detection circuitry only. This does not affect the coupling of the signal being measured.

<i>coupling</i> parameter	Numeric query equiv.	Description
DC	1	Selects DC-coupled input to level-detection circuitry
AC	2	Selects AC-coupled input to level-detection circuitry

Power-on *coupling* = AC.

Default *coupling* = AC.

Remarks

- Level triggering can be used for DC voltage, direct-sampling, and sub-sampling. (The LEVEL command also affects the zero crossing threshold and the input signal coupling for frequency and period measurements.) For DC voltage and direct-sampling, level triggering can be used as the trigger event (TRIG LEVEL command) or the sample event (NRDGS n, LEVEL command). For sub-sampling, level triggering can be used for the sync source event only (SSRC LEVEL command).
- Because of hysteresis, the actual level triggering point is the specified *percentage* $\pm 4\%$ of the measurement range.
- Autozero should be disabled when using level triggering (AZERO OFF command) for DC voltage measurements. (Autozero doesn't apply to direct- or sub-sampling.)
- **Query command:** The LEVEL? query command returns two responses separated by a comma. The first response is the currently specified *percentage*. The second response is the present coupling mode. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** DCV, DSAC, DSDC, LFILTER, NRDGS, SETACV, SYNC, SLOPE, SSAC, SSDC, SSRC, TRIG

Example

```

10 OUTPUT 722;"TARM HOLD" !SUSPENDS TRIGGERING
20 OUTPUT 722;"PRESET DIG" !FAST DCV MEASUREMENTS, 10 V RANGE
30 OUTPUT 722;"TRIG LEVEL" !SELECT LEVEL TRIGGER EVENT
40 OUTPUT 722;"SLOPE POS" !TRIGGER ON POSITIVE SLOPE OF SIGNAL
50 OUTPUT 722;"LEVEL 50,AC" !TRIGGER AT 50% OF 10 V RANGE (5 V)
AC-COUPLED
60 END

```

LFILTER

Level filter. Enables or disables the level filter function. When enabled, the level filter function connects a single pole low-pass filter circuit to the input of the level-detection circuitry. The low-pass filter has a 3-dB point of 75 kHz and prevents high frequency components from causing false triggers.

Syntax

LFILTER [*control*]

control

The *control* parameter choices are:

<i>control</i> parameter	Numeric query equiv.	Description
OFF	0	Disables the level filter; no filtering is done
ON	1	Enables the level filter

Power-on *control* = OFF.

Default *control* = ON.

Remarks

- Level filtering can be used when level triggering for DC voltage, direct- and sub-sampling. The level filter can also be used to reduce sensitivity to noise for frequency and period measurements or when making AC or AC+DC voltage measurements using the synchronous method (SETACV SYNC command).
- **Query command:** The LFILTER? query command returns the present level filter mode. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** DCV, DSAC, DSDC, FREQ, LEVEL, NRDGS, PER, SETACV, SYNC, SLOPE, SSAC, SSDC, SSRC, TRIG

Example

OUTPUT 722;"LFILTER ON" !ENABLES THE LEVEL FILTER

LFREQ

The LFREQ command allows you to specify the A/D converter's reference frequency or measure the line frequency and set the reference frequency to the measured value.

Syntax

LFREQ [*frequency*]

or

LFREQ LINE

frequency

Allows you to specify the reference frequency. The valid range for the *frequency* parameter is 45 - 65 Hz, or 360 - 440 Hz. When you specify a frequency in the range of 360 - 440 Hz, the multimeter divides that value by 8. For example, if you specify LFREQ 400, the multimeter sets the reference frequency to $400/8 = 50$ Hz.

Power-on reference frequency = rounded value of 50 or 60 Hz (see first Remark below).

Default reference frequency = the exact measured line frequency (or measured value/8 for 400 Hz line frequency).

LINE

Measures the exact value of the line frequency and sets the reference frequency to that value (or measured value/8 if the measured value is between 360 and 440 Hz).

Remarks

- When power is applied, the multimeter measures the line frequency, rounds it to 50 or 60 Hz, and sets the A/D Converter's reference frequency to the rounded value. (For a 400 Hz power line frequency, the multimeter uses 50 Hz as a reference frequency which is a subharmonic of 400 Hz.)
- The step size for the period of the reference frequency is 100 ns. For example, the period of a 60 Hz reference frequency is $1/60 \text{ Hz} = .0166666...$ Since the step size is 100 ns, the multimeter uses the value of .0166667 s. The step size is most noticeable when using the LFREQ? query command. For example, if

you have specified 60 Hz as the reference frequency, the LFREQ? returns 59.99988 (1/.0166667).

- The multimeter multiplies the period of the reference frequency times the specified number of power line cycles (NPLC command) to determine the actual integration time. The multimeter's normal mode noise rejection (NMR) specifications for DC and resistance measurements are related to the accuracy of the A/D converter's reference frequency.
- **Query command:** The LFREQ? query command returns the present value of the line frequency reference used by the multimeter's A/D converter. Since the step size is 100 ns, if the period of the value specified is not evenly divisible by 1/100 ns, the value returned by LFREQ? will be slightly different than the value specified. Refer to **Query commands** near the front of this chapter for more information.
- **Related commands:** LINE?, NPLC

Example

```
OUTPUT 722; "LFREQ LINE" !MEASURES LINE FREQUENCY, SETS REFERENCE
!FREQUENCY TO MEASURED VALUE (OR MEASURED
!VALUE/8 FOR 400 HZ LINE FREQUENCY)
```

LINE?

Line frequency query. Measures and returns the frequency of the AC power line.

Syntax

LINE?

Remarks

- Refer to the **LFREQ** command on the previous page for an example showing how to measure the line frequency and automatically set the A/D converter's reference frequency to the measured value.
- **Related commands:** LFREQ

Example

```

10 OUTPUT 722; "LINE?" !MEASURES THE LINE FREQUENCY
20 ENTER 722;A !ENTERS RESPONSE INTO COMPUTER'S A VARIABLE
30 PRINT A !PRINTS RESPONSE
40 END

```

LOCK

Lockout. Enables or disables the multimeter's keyboard

Syntax

LOCK [*control*]

control

The *control* parameter choices are:

<i>control</i> parameter	Numeric query equiv.	Description
OFF	0	Enables the keyboard (normal operation)
ON	1	Disables the keyboard (pressing keys has no affect)

Power-on *control* = OFF.

Default *control* = ON.

Remarks

- The LOCK command is accessible from the front panel's alphabetic command directory. However, executing the LOCK command from the front panel has no effect.
- After disabling the keyboard, you can only enable it from the controller or by cycling power. The LOCK command disables the multimeter's **Local** key.
- **Query command:** The LOCK? query command returns the present LOCK mode. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** LOCAL LOCKOUT (GPIB command)

Example

OUTPUT 722;"LOCK ON" !DISABLES THE KEYBOARD

MATH

The MATH command enables or disables real-time math operations.

Syntax

MATH [*operation_a*][,*operation_b*]

operation

The operation parameter choices are:

<i>operation parameter</i>	Numeric equiv.	Description
OFF	0	Disables all enabled real-time math operations
CONT	1	Enables the previous math operation. To resume two math operations, send MATH CONT,CONT
CTHRM	3	Result = temperature (Celsius) of a 5 k Ω thermistor (40653B). Function must be OHM or OHMF (10 k Ω range or higher).
DB	4	Result = $20 \times \log_{10}(\text{reading}/\text{REF register})$. The REF register is initialized to 1, yielding dBV.
DBM	5	Result = $10 \times \log_{10}(\text{reading}^2/\text{RES register}/1 \text{ mW})$. Function must be ACV, DCV, or ACDCV.
FILTER	6	Result = output of exponentially weighted digital low-pass filter. Response is set by DEGREE register.
FTHRM	8	Result = temperature (Fahrenheit) of a 5 k Ω thermistor (40653B). Function must be OHM or OHMF (10 k Ω range or higher).
NULL	9	Result = reading-OFFSET register. The OFFSET register is set to first reading—after that you can change it.
PERC	10	Result = $((\text{reading} - \text{PERC register}) / \text{PERC register} \times 100)$.
PFAIL	11	Reading vs. MAX and MIN registers.

<i>operation parameter</i>	Numeric equiv.	Description
RMS	12	Result = squares reading, applies FILTER operation, takes square root.
SCALE	13	Result = (reading-OFFSET register) / SCALE register.
STAT	14	Performs statistical calculations on the present set of readings and stores results in these registers: SDEV = standard deviation MEAN = average of readings NSAMP = number of readings UPPER = largest reading LOWER = smallest reading
CTHRM2K	16	Result = temperature (Celsius) of a 2 k Ω thermistor (40653A). Function must be OHM or OHMF.
CTHRM10K	17	Result = temperature (Celsius) of a 10 k Ω thermistor (40653C). Function must be OHM or OHMF.
FTHRM2K	18	Result = temperature (Fahrenheit) of a 2 k Ω thermistor (40653A). Function must be OHM or OHMF.
FTHRM10K	19	Result = temperature (Fahrenheit) of a 10 k Ω thermistor (40653C). Function must be OHM or OHMF.
CRTD85	20	Result = temperature (Celsius) of 100 Ω RTD with alpha of 0.00385 (40654A or 406548). Function must be OHM or OHMF.
CRTD92	21	Result = temperature (Celsius) of 100 Ω RTD with alpha of 0.003916. Function must be OHM or OHMF.
FRTD85	22	Result = temperature (Fahrenheit) of 100 Ω RTD with alpha of 0.00385 (40654A or 406548). Function must be OHM or OHMF.
FRTD92	23	Result = temperature (Fahrenheit) of 100 Ω RTD with alpha of 0.003916. Function must be OHM or OHMF.

Power-on *operation_a,operation_b* = OFF,OFF.

Default *operation_a,operation_b* = OFF,OFF.

Power-on *register* values = all registers are set to 0 with the following exceptions:

DEGREE = 20	REF = 1
SCALE = 1	RES = 50
PERC = 1	

Remarks

- The FILTER, RMS, STAT, or PFAIL math operations are performed on all subsequent readings. However, whenever the multimeter's configuration is changed, the previous math results are erased and the operation starts over on the new readings. All other math operations stay enabled until you set MATH OFF, execute the MATH command specifying other math operation(s), or enable post-process math operation(s) (except MMATH PFAIL or MMATH STAT as described under the MMATH command).
- When two real-time math operations are enabled, *operation_a* is performed on the reading first. Next, *operation_b* is performed on the result of the first operation.
- When a real-time math operation is enabled, the display's half digit becomes a full digit. For example, if you are making 4.5 digit AC voltage measurements and then enable the SCALE math operation, the display is capable of showing 5 full digits.
- Math registers may be written to with the SMATH command. Math registers may be read with the RMATH command.
- **Query command:** The MATH? query command returns two responses, separated by a comma, which indicate the enabled real-time math function(s). Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** MMATH, RMATH, SMATH

Example

The following program performs the real-time NULL math operation on 20 readings. After executing the NULL command, the first reading is triggered by line 50. The value in the OFFSET register is then changed to 3.05. The 20 readings are triggered by line 90 and 3.05 is subtracted from each reading.

```
10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
```

```

20 DIM Rdgs(20) !DIMENSION ARRAY FOR 20 READINGS
30 OUTPUT 722;"PRESET NORM" !PRESET, NRDGS 1,AUTO, DCV 10
40 OUTPUT 722;"MATH NULL" !ENABLE REAL-TIME NULL MATH OPERATION
50 OUTPUT 722;"TRIG SGL" !TRIGGER 1 READING, STORED IN OFFSET
60 OUTPUT 722;"SMATH OFFSET,3.05" !WRITE 3.05 TO OFFSET REGISTER
70 OUTPUT 722;"NRDGS 20" !20 READINGS PER TRIGGER
80 OUTPUT 722;"TRIG SYN" !SYN TRIGGER EVENT
90 ENTER 722;Rdgs(*) !SYN EVENT, ENTER NULL CORRECTED READINGS
100 PRINT Rdgs(*) !PRINT NULL CORRECTED READINGS
110 END

```

MCOUNT?

Memory count query. Returns the total number of stored readings.

Syntax

MCOUNT?

Remarks

- **Related commands:** MEM, MFORMAT, MSIZE, RMEM

Example

```

10 OUTPUT 722; "MCOUNT?" !RETURNS TOTAL NUMBER OF STORED READINGS
20 ENTER 722;A !ENTERS RESPONSE INTO A VARIABLE
30 PRINT A !PRINTS RESPONSE
40 END

```

MEM

Memory. Enables or disables reading memory and designates the storage mode.

Syntax

MEM [*mode*]

mode

The *mode* parameter choices are:

<i>mode</i> parameter	Numeric query equiv.	Description
OFF	0	Stops storing readings (stored readings stay intact)
LIFO	1	Clears reading memory and stores new readings LIFO (last-in-first-out)
FIFO	2	Clears reading memory and stores new readings FIFO (first-in-first-out)
CONT	3	Keeps memory intact and selects previous mode (if there was no previous mode, FIFO is selected)

Power-on *mode* = OFF.

Default *mode* = ON.

Remarks

- In the high-speed mode, when reading memory is enabled in the FIFO mode and becomes full, the trigger arm event becomes HOLD which stops readings and removes the multimeter from the high-speed mode. After removing some or all of the readings from memory, you can resume measurements by changing the trigger arm event (TARM command). When not in the high-speed mode, when you fill memory in the FIFO mode, the stored readings remain intact and new readings are not stored. In the LIFO mode, when reading memory becomes full, the oldest readings are replaced with the newest readings regardless of whether in the high-speed mode or not.
- When the controller requests data from the multimeter and its output buffer is empty in the LIFO or FIFO mode, a reading is removed from memory and sent to the controller. This is the “implied read” method of recalling readings. In the LIFO mode, the most recent reading is returned. In the FIFO mode, the oldest reading is returned. The reading storage mode (LIFO or FIFO) is important only when you are using the “implied read” method of recalling readings. The reading storage mode has no effect on readings recalled using the RMEM command.

- Use the MFORMAT command to specify the memory format (SINT, DINT, ASCII, SREAL, or DREAL).
- Executing the RMEM command sets reading memory to OFF. You must execute MEM CONT, MEM FIFO, or MEM LIFO to re-enable reading memory after executing RMEM.
- **Query command:** The MEM? query command returns the present memory mode. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** MCOUNT?, MFORMAT, MSIZE, RMEM

Example

OUTPUT 722;"MEM FIFO" !ENABLES READING MEMORY, FIFO MODE

MENU

The MENU command selects the SHORT or FULL list of commands in the front panel's alphabetic command menu.

Syntax

MENU [*mode*]

mode

The *mode* parameter choices are:

<i>mode</i> parameter	Numeric query equiv.	Description
SHORT	0	Selects the short command menu
FULL	1	Selects the full command menu

Power-on *mode* = mode selected when power was removed.
Default *mode* = FULL

Remarks

- To access the alphabetic command menu, press any of the shifted MENU keys labeled C, E, L, N, R, S, and T. You can then locate a particular command using the up and down arrow keys.
- The *mode* parameter is stored in continuous memory (not lost when power is removed).
- The FULL menu contains all commands except query commands that can be made by accessing a command and appending a question mark (e.g., BEEP, BEEP?). The SHORT menu eliminates the GPIB bus-related commands and any commands that have dedicated front panel keys (e.g., RSTATE command, **Recall State** key).
- **Query command:** The MENU? query command returns a response indicating the present menu mode. Refer to **Query commands** near the front of this chapter for more information.
- **Related commands:** DEFKEY, LOCK

Example

OUTPUT 722;"MENU SHORT" !SELECTS SHORT MENU

MFORMAT

Memory format. Clears reading memory and designates the storage format for new readings.

Syntax

MFORMAT [*format*]

format

The *format* parameter choices are:

<i>format</i> parameter	Numeric query equiv.	Description
ASCII	1	ASCII-16 bytes per reading ^[a]
SINT	2	Single Integer-16 bits 2's complement (2 bytes per reading)

<i>format</i> parameter	Numeric query equiv.	Description
DINT	3	Double Integer-32 bits 2's complement (4 bytes per reading)
SREAL	4	Single Real-(IEEE-754) 32 bits (4 bytes per reading)
DREAL	5	Double Real-(IEEE-754) 64 bits (8 bytes per reading)

[a] The ASCII format is actually 15 bytes for the reading plus 1 byte for a null character which is used to separate stored ASCII readings only.

Power-on *format* = SREAL.

Default *format* = SREAL.

Remarks

- The multimeter indicates an overload by storing the value $\pm 1\text{E}+38$ in memory instead of the reading. When overload values are recalled to the display, the value $\pm 1\text{E}+38$ is displayed. When overload values are transferred from reading memory to the GPIB output buffer, they are converted to the overload number for the specified output format. (See the **OFORMAT** command for details.)
- When using the SINT or DINT memory format, the multimeter stores each reading assuming a certain scale factor. This scale factor is based on the present measurement function, range, A/D setting, and enabled math operations. When you recall a reading, the multimeter calculates the scale factor based on the present measurement function, range, A/D setting, and enabled math operations. It then multiplies the scale factor by the stored reading and sends the result (recalled reading) to the display or the output buffer. Therefore, always ensure that the multimeter's configuration is the same when storing and recalling data in the SINT or DINT format.
- You should not use the SINT or DINT output or memory format for frequency or period measurements when a real-time or post-process math function is enabled (except STAT or PFAIL) or when autorange is enabled.
- The memory format does not affect the output format specified by the OFORMAT command.
- You enable reading memory using the MEM command. You access stored readings using the RMEM command or by using the “implied read.” The “implied read” is discussed under **Using Reading Memory** in **Chapter 4**.

- When using reading memory for sub-sampled measurements (SSAC or SSDC command), the memory format must be set to SINT, the memory mode must be FIFO (MEM FIFO command), and reading memory must be empty (done by executing the MEM FIFO command) before samples are taken. If these requirements are not met when the trigger arm event occurs, an error is generated.
- **Query command:** The MFORMAT? query command returns the present memory format. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** MCOUNT?, MEM, MSIZE, RMEM

Example

```
10 OUTPUT 722;"NPLC 10" !10 PLCS OF INTEGRATION TIME
20 OUTPUT 722;"DCV 7" !DC VOLTAGE, 10 V RANGE
30 OUTPUT 722;"MATH OFF" !SHUTS OFF MATH FUNCTIONS
40 OUTPUT 722;"MEM FIFO" !ENABLES READING MEMORY (FIFO MODE)
50 OUTPUT 722;"MFORMAT DINT" !SELECTS DINT MEMORY FORMAT
60 END
```

When recalling the stored data, make sure that the multimeter is configured as it was when you stored the data.

MMATH

Memory math. Enables or disables post-process math operations.

Syntax

MMATH [*operation_a*] [,*operation_b*]

operation

The operation parameter choices are:

<i>operation parameter</i>	Numeric Equiv.	Description
OFF	0	Disables all post-process math operations
CONT	1	Enables the previous math operation. To resume two math operations, send MMATH CONT,CONT
CTHRM	3	Result = temperature (Celsius) of a 5 k Ω thermistor (40653B). Function must be OHM or OHMF (10 k Ω range or higher).
DB	4	Result = $20 \times \log_{10}$ (reading/REF register). The REF register is initialized to 1, yielding dBV.
DBM	5	Result = $10 \times \log_{10}$ (reading ² /RES register/1 mW). Function must be ACV, DCV, or ACDCV.
FILTER	6	Result = output of exponentially weighted digital low-pass filter. Response is set by DEGREE register.
FTHRM	8	Result = temperature (Fahrenheit) of a 5 k Ω thermistor (40653B). Function must be OHM or OHMF (10 k Ω range or higher).
NULL	9	Result = reading-OFFSET register. The OFFSET register is set to first reading—after that you can change it.
PERC	10	Result = ((reading - PERC register) / PERC register) x 100.
PFAIL	11	Reading vs. MAX and MIN registers.
RMS	12	Result = squares reading, applies FILTER operation, takes square root.
SCALE	13	Result = (reading-OFFSET register) / SCALE register.
STAT	14	Performs statistical calculations on the present set of readings and stores results in these registers: SDEV = standard deviation MEAN = average of readings NSAMP = number of readings UPPER = largest reading LOWER = smallest reading
CTHRM2K	16	Result = temperature (Celsius) of a 2 k Ω thermistor (40653A). Function must be OHM or OHMF.
CTHRM10K	17	Result = temperature (Celsius) of a 10 k Ω thermistor (40653C). Function must be OHM or OHMF.

<i>operation parameter</i>	<i>Numeric Equiv.</i>	<i>Description</i>
FTHRM2K	18	Result = temperature (Fahrenheit) of a 2 k Ω thermistor (40653A). Function must be OHM or OHMF.
FTHRM10K	19	Result = temperature (Fahrenheit) of a 10 k Ω thermistor (40653C). Function must be OHM or OHMF.
CRTD85	20	Result = temperature (Celsius) of 100 Ω RTD with alpha of 0.00385 (40654A or 40654B). Function must be OHM or OHMF.
CRTD92	21	Result = temperature (Celsius) of 100 Ω RTD with alpha of 0.003916. Function must be OHM or OHMF.
FRTD85	22	Result = temperature (Fahrenheit) of 100 Ω RTD with alpha of 0.00385 (40654A or 40654B). Function must be OHM or OHMF.
FRTD92	23	Result = temperature (Fahrenheit) of 100 Ω RTD with alpha of 0.003916. Function must be OHM or OHMF.

Power-on *operation_a,operation_b* = OFF,OFF.

Default *operation_a,operation_b* = OFF,OFF.

Power-on *register* values = a11 registers are set to 0 with the following exceptions:

DEGREE = 20 REF = 1
 SCALE = 1 RES = 50
 PERC = 1

Remarks

- Any enabled post-process math operations except STAT and PFAIL are performed on each reading as it is removed or copied from reading memory to the display or the GPIB output buffer. (The readings in memory are not altered by any post-process math operation.) The STAT or PFAIL post-process math operations are performed using the readings in memory immediately after executing the MMATH command. (The STAT and PFAIL operations are not updated for any additional readings placed in memory after executing the MMATH command.)

- For the STAT operation, results are stored in the SDEV, MEAN, NSAMP, UPPER, and LOWER math registers (refer to the **RMATH** command for information on these registers).
- For the PFAIL operation, whenever an out of limit reading is detected, bit number 1 in the status register is set (this sets the GPIB SRQ line if enabled by the RQS command) and the display shows the FAILED LOW or FAILED HIGH message.
- An enabled post-process math operation remains enabled until you set MMATH OFF, enable a real-time math operation (MATH command), or execute the MMATH command specifying another math operation (except as described in the following remark).
- When MMATH is executed from the front panel, the result goes to the display only. When MMATH is executed from remote, the result goes to the output buffer only.
- When two post-process math operations are enabled, *operation_a* is performed on the reading first. Next, *operation_b* is performed on the result of the first operation.
- When a post-process math operation is enabled, the display's half digit becomes a full digit. For example, if you are making 4.5 digit AC voltage measurements and then enable the SCALE operation, the display is capable of showing 5 full digits.
- Math registers may be written to with the SMATH command. Math registers may be read with the RMATH command.
- **Query command:** The MMATH? query command returns two responses (separated by a comma) which indicate the currently enabled post-process math functions.
- When you use the RMEM command to recall readings, it turns off reading memory. This means any new readings will not be placed in reading memory and cannot have an enabled memory math operation performed on them. When you use the “implied read” method to recall readings, reading memory is not turned-off.
- **Related commands:** MATH, MEM, RMATH, RMEM, SMATH

Example

The following program performs the post-process NULL operation on 20 readings. After executing the MMATH NULL command, 21 readings are taken and stored in reading memory in FIFO mode. Line 80 recalls the first reading taken which is stored in the OFFSET register. The value in the OFFSET register is then changed to 3.05. The remaining 20 readings in memory are recalled and the NULL operation is performed on each.

```

10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(20) !DIMENSION ARRAY FOR 20 READINGS
30 OUTPUT 722; "PRESET NORM" !PRESET, NRDGS 1,AUTO, DCV 10
40 OUTPUT 722;"MEM FIFO" !ENABLE READING MEMORY, FIFO MODE
50 OUTPUT 722;"MMATH NULL" !ENABLE POST-PROCESS NULL OPERATION
60 OUTPUT 722;"NRDGS 21" !21 READINGS PER TRIGGER
70 OUTPUT 722;"TRIG SGL" !TRIGGER READINGS
80 ENTER 722;A !RECALL FIRST READING USING IMPLIED READ
90 OUTPUT 722; "SMATH OFFSET, 3.05" !WRITE 3.05 TO OFFSET REGISTER
100 ENTER 722;Rdgs(*) !RECALL READINGS USING IMPLIED READ,
105 !PERFORM NULL OPERATION ON EACH
110 PRINT Rdgs(*) !PRINT NULL MODIFIED READINGS
120 END

```

MSIZE

Memory size. On a previous multimeter, the MSIZE command was used to clear all memory and allocate memory space for readings, subprograms, and state storage. The 3458A accepts the MSIZE command to maintain language compatibility, but performs no action since the 3458A's memory allocations are predefined and cannot be changed. The MSIZE? query command, however, is useful to determine the total reading memory and the largest unused block of subprogram/state memory.

Syntax

MSIZE [*reading_memory*][*,subprogam_memory*]

Remarks

- As subprogram/state memory is used, it eventually becomes fragmented into many small blocks. The MSIZE? command returns the total number of bytes of reading memory and the number of bytes of the largest unused block of subprogram/state memory. The SCRATCH command clears all subprograms and states from memory returning these memory areas to one contiguous block. Also, when power is cycled, the multimeter combines fragmented blocks of memory wherever possible.
- **Query command:** The MSIZE? query command returns two responses separated by a comma. The first response is the total number of bytes of reading memory. The second response is the largest block (in bytes) of unused subprogram/state memory.
- **Related commands:** MCOUNT?, MEM, MFORMAT, RMEM, DELSUB, SCRATCH, SUB, SUBEND, SSTATE

Example

```
10 OUTPUT 722; "MSIZE?" !QUERY MEMORY SIZES
20 ENTER 722;A,B !ENTER RESPONSES
30 PRINT A,B !PRINT RESPONSES
40 END
```

NDIG

Number of digits. Designates the number of digits to be displayed by the multimeter.

Syntax

NDIG [*value*]

value

The *value* parameter can be an integer from 3 to 8 (there is an implied ½ digit; that is, when you specify NDIG 3, the multimeter displays 3½ digits.)

Power-on *value* = 7 (7½ digits).

Default *value* = 7 (7½ digits).

Remarks

- The NDIG command sets the maximum number of digits displayed. It does not affect the A/D converter's resolution or readings sent to memory or the GPIB bus. The multimeter cannot display more digits than are resolved by the A/D converter.
- **Query command:** The NDIG? query command returns the currently specified number of digits. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** DISP

Example

```
10 OUTPUT 722; "RESET" !RETURN TO POWER-ON STATE
20 OUTPUT 722;"NDIG 8" !DISPLAY 8 1/2 DIGITS
30 END
```

NPLC

Number of power line cycles. Specifies the A/D converter's integration time in terms of power line cycles. Integration time is the time during which the A/D converter measures the input signal.

Syntax

NPLC [*power_line_cycles*]

power_line_cycles

The primary use of the NPLC command is to establish normal mode noise rejection (NMR) at the A/D converter's reference frequency (LFREQ command). Any value ≥ 1 for the *power_line_cycles* parameter provides at least 60 dB of NMR at the power line frequency. Any value < 1 provides no NMR; it only sets the integration time for the A/D converter. The ranges and the incremental step sizes for the *power_line_cycles* parameter are:

0 - 1 PLC in .000006 PLC steps for 60 Hz reference frequency (LFREQ command)

or

0 - 1 PLC in .000005 PLC steps for 50 Hz reference frequency

1 - 10 PLC in 1 PLC steps

10 - 1000 PLC in 10 PLC steps.

Power-on *power_line_cycles* = 10

Default *power_line_cycles* = 0 (selects minimum integration time of 500 ns)

The relationship of the integration time (expressed in PLCs), the A/D converter's reference frequency (LFREQ command), and the digits of resolution is:

Digits of resolution			Power line cycles (NPLC command)	
DCV	DCI, OHM(F)	ACI, ACDCI, ACV ^[a] , ACDCV ^[a]	Reference frequency (LFREQ) = 60 Hz	Reference frequency (LFREQ) = 50 Hz
4.5	4.5	4.5	0 - .000030	0 - .000025
5.5	5.5	5.5	.000036 - .000360	.000030 - .000300
6.5	6.5	6.5	.000366 - .030000	.000305 - .025000
7.5	7.5 ^[b]	6.5	.030006 - 1	.025005 - 1
8.5 ^[b]	7.5 ^[b]	6.5	2 - 1000	2 - 1000

[a] Analog measurement method only (SETACV ANA command)

[b] For all ranges except the 10 Ω OHM(F) range and the 100 mV DCV range. The 10 Ω OHM(F) range has a maximum of 6.5 digits and the 100 mV DCV range has a maximum of 7.5 range.

Remarks

- For the ACV and ACDCV (SETACV ANA method only), ACT, ACDCI, DCI, DCV, OHM, and OHMF measurement functions, resolution is determined by the A/D converter's integration time. The integration time has no effect on FREQ or PER. For sampled ACV or ACDCV (SETACV SYNC or SETACV RNDM), the integration time is selected automatically and the specified resolution is achieved by varying the number of samples taken. For direct- or sub-sampled digitizing, the integration time is fixed and cannot be changed.
- Since the NPLC and APER commands both set the integration time, executing either will cancel the integration time previously established by the other. The RES command or the *%_resolution* parameter of a function command or the RANGE command can also be used to indirectly select an integration time. An

interaction occurs between NPLC (or APER) when you specify resolution as follows:

- If you send the NPLC (or APER) command *before* specifying resolution, the multimeter satisfies the command that specifies greater resolution (more integration time).
- If you send the NPLC (or APER) command *after* specifying resolution, the multimeter uses the integration time specified by the NPLC (or APER) command, and any previously specified resolution is ignored.
- The more common approach is the first of the two shown above; i.e., the NPLC command is executed first to establish normal mode noise rejection (NMR), then *%_resolution* is specified with a function or RANGE command. This ensures you will have NMR and at least the required resolution.
- **Query command:** The NPLC? query command returns the integration time (in units of PLCs) used by the A/D converter. Since the integration time can be set by the APER, NPLC, or RES command, or the *%_resolution* parameter of a function command or the RANGE command, it is possible for the NPLC? command to return a different number of PLCs than was last specified by the NPLC command.
- **Related commands:** APER, FUNC, LFREQ, RES

Examples

In the following program, line 10 sets the number of PLCs to minimum and allows *%_resolution* in line 20 to control the resolution. The resolution specified by line 20 is 100 μV .

```
10 OUTPUT 722;"NPLC 0" !SETS PLCS TO MINIMUM
20 OUTPUT 722;"DCV 6,.00167" !DC VOLTS, 6 V MAX, 100  $\mu\text{V}$  RESOLUTION
30 END
```

In the following program, line 10 sets the number of PLCs to 1000. This corresponds to maximum resolution and prevents *%_resolution* in line 20 from affecting the measurement. The requested resolution from line 20 is 10 $\text{m}\Omega$. However, because of line 10, the actual resolution is 100 $\mu\Omega$.

```
10 OUTPUT 722;"NPLC 1000" !SETS PLCS TO MAXIMUM
20 OUTPUT 722;"OHM 1E3,.001" !SELECTS 2-WIRE OHMS, 1  $\text{k}\Omega$  MAX INPUT
30 END
```

NRDGS

Number of readings. Designates the number of readings taken per trigger and the event (sample event) that initiates each reading.

Syntax

NRDGS [*count*][*,event*]

count

Designates the number of readings per trigger event. The valid range for this parameter is 1 to 16777215. (The *count* parameter also corresponds to the record parameter in the RMEM command. Refer to the **RMEM** command for details.)

Power-on *count* = 1.

Default *count* = 1.

event

Designates the event that initiates each reading (sample event). The *event* parameter choices are:

<i>event</i> parameter	Numeric query equiv.	Description
AUTO	1	Initiates reading whenever the multimeter is not busy
EXTSYN	2	Initiates reading on negative edge transition on the multimeter's external trigger input connector
SYN	5	Initiates reading when the multimeter's output buffer is empty, reading memory is off or empty, and the controller requests data.
TIMER ^[a]	6	Similar to AUTO with a time interval between successive readings (specify interval with the TIMER command)
LEVEL ^[b]	7	Initiates reading when the input signal reaches the voltage specified by the LEVEL command on the slope specified by the SLOPE command.
LINE ^[a]	8	Initiates reading on a zero crossing of the AC line voltage

[a] The TIMER or LINE event cannot be used for sampled AC or AC+DC voltage measurements (SETACV RNDM or SYNC) or for frequency or period measurements.

[b] The LEVEL sample event can be used only for DC voltage and direct-sampled measurements.

Power-on *event* = AUTO.

Default *event* = AUTO.

Remarks

- Since the TIMER event designates an interval between readings, it only applies when *count* is greater than one. The first reading occurs without the TIMER interval. However, you can insert a time interval before the first reading with the DELAY command. (The TIMER event suspends autoranging.)
- You can use the SWEEP command to replace the two commands: NRDGS *n*, TIMER and TIMER *n*. The SWEEP command specifies the number of readings and the interval between readings. These commands are interchangeable; the multimeter uses whichever command was executed last in the programming. Executing the SWEEP command automatically sets the sample event to TIMER. In the power-on, RESET, and PRESET states, the multimeter uses the NRDGS command.
- When SYN is used for more than one of the trigger arm, trigger, or sample events, a single occurrence of the SYN event satisfies all of the specified SYN event requirements. This is shown in the second “SYN event” example below.
- **Query command:** The NRDGS? query command returns two responses separated by a comma. The first response is the specified number of readings per trigger. The second response is the present sample event. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** DELAY, LEVEL, RMEM, SLOPE, TARM, TIMER, TRIG, SWEEP

Examples

SYN event

In the following program, line 70 requests data from the multimeter. This satisfies the SYN event and initiates a reading. The reading is then sent to the controller and printed. The process repeats until the three readings have been taken and printed.

```
10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM A(3) !DIMENSION ARRAY
30 OUTPUT 722;"DCV 8,.00125" !DC VOLTAGE, 10 V RANGE, 100 µV RESOLUTION
40 OUTPUT 722;"NRDGS 3, SYN" !3 READINGS/TRIGGER, SYN SAMPLE EVENT
```

```

50 OUTPUT 722;"TRIG AUTO" !AUTO TRIGGER MODE
60 ENTER 722;A(*) !ENTER READINGS
70 PRINT A(*) !PRINT READINGS
80 END

```

In the following example, SYN is specified for the trigger arm, trigger, and sample events. Five readings per trigger are specified. A single occurrence of the SYN event (line 60) satisfies the trigger arm, trigger, and the first sample event and initiates the first reading. Four more SYN events (one for each reading) are then required to initiate the remaining four readings.

```

10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(5) !DIMENSION ARRAY FOR READINGS
30 OUTPUT 722;"PRESET NORM" !SYN TRIGGER EVENT, DCV, NPLC 1, MEM OFF
40 OUTPUT 722;"TARM SYN" !SYN TRIGGER ARM EVENT
50 OUTPUT 722;"NRDGS 5, SYN" !5 READINGS/TRIGGER, SYN SAMPLE EVENT
60 ENTER 722;Rdgs(*) !SYN EVENT, ENTER READINGS
70 PRINT Rdgs(*) !PRINT READINGS
80 END

```

TIMER

The following program makes 4 readings in response to the synchronous trigger (line 60). The first reading is made immediately after the preprogrammed default delay; the remaining 3 have a 200 ms interval between them.

```

10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM Rdgs(4) !DIMENSION ARRAY FOR READINGS
30 OUTPUT 722;"PRESET NORM" !TARM AUTO,TRIG SYN,DCV AUTORANGE
40 OUTPUT 722;"TIMER 200E-3" !SETS TIMER INTERVAL TO 200 m SECONDS
50 OUTPUT 722;"NRDGS 4,TIMER" !SELECTS 4 READINGS/TRIGGER & TIMER
60 ENTER 722;Rdgs(*) !TRIGGER AND ENTER READINGS
70 PRINT Rdgs(*) !PRINT READINGS
80 END

```

OCOMP

The OCOMP command enables or disables the offset compensated ohms function.

Syntax

OCOMP [*control*]

control

The *control* parameter choices are:

<i>control parameter</i>	Numeric query equiv.	Description
OFF	0	Offset compensated ohms disabled.
ON	1	Offset compensated ohms enabled.

Power-on *control* = OFF.

Default *control* = ON.

Remarks

- With offset compensation enabled, the multimeter measures the external offset voltage (with the ohms current source shut off) before each resistance reading and subtracts the offset from the following reading. This prevents the offset voltage from affecting the resistance reading, but it doubles the time required per reading.
- You can use offset compensated ohms on both 2-wire and 4-wire resistance measurements. When you have offset compensation enabled and change from ohms to some other measurement function (DCV, ACV, etc.), offset compensation is temporarily disabled. When you return to 2-wire or 4-wire ohms, however, offset compensation is once again enabled.
- The multimeter can only perform offset compensation on the 10 Ω through 100 k Ω ranges. If OCOMP is enabled when using the 1 M Ω through 1 G Ω ranges, readings are made without offset compensation.

- **Query command:** The OCOMP? query command returns the present offset compensation mode. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** OHM, OHMF

Example

OUTPUT 722;"OCOMP ON" !ENABLES OFFSET COMPENSATION

OFORMAT

Output format. Designates the GPIB output format for readings sent directly to the controller or transferred from reading memory to the controller.

Syntax

OFORMAT [*format*]

format

The *format* parameter choices are:

<i>format</i> parameter	Numeric query equiv.	Descriptions
ASCII	1	ASCII-15 bytes per reading (see 1st and 2nd Remarks below)
SINT	2	Single Integer-16 bits 2's complement (2 bytes per reading)
DINT	3	Double Integer-32 bits 2's complement (4 bytes per reading)
SREAL	4	Single Real-(IEEE-754) 32 bits, (4 bytes per reading)
DREAL	5	Double Real-(IEEE-754) 64 bits, (8 bytes per reading)

Power-on *format* = ASCII.

Default *format* = ASCII.

Remarks

- The ASCII output format sends the *cr lf* (carriage return, line feed) to indicate the end of the transmission to most computers. The SINT, DINT, SREAL, and DREAL output formats, however, do not send *cr lf*. With any format, you can

use the END command to indicate the end of the transmission using the GPIB EOI function. Refer to the **END** command for more information.

- When using the ASCII format, 2 additional bytes are required for the carriage-return, line-feed (*cr,lf*) end of line sequence. The *cr,lf* is used only for the ASCII format and normally follows each reading output in ASCII format. However, when using the ASCII output format and multiple readings are recalled from reading memory using the RMEM command, the multimeter places a comma between readings (comma = 1 byte). In this case, the *cr,lf* occurs only once, following the last reading in the group being recalled. Commas are not used when readings are output directly to the bus (reading memory disabled), when readings are recalled using “implied read,” or when using any other output format.
- The multimeter indicates an overload condition (input greater than the present range can measure) by outputting the largest number possible for the particular output format as follows.

SINT format: +32767 or -32768 (unscaled)

DINT format: +2.147483647E+9 or -2.147483648E+9 (unscaled)

ASCII, SREAL, DREAL: +/-1.0E+38

- When reading memory is disabled, executing the SSAC or SSDC command (sub-sampling) automatically sets the output format to SINT regardless of the previously specified format. You must use the SINT output format when sub-sampling and not using reading memory.
- The output format applies only to readings transferred over the GPIB bus. Responses to query commands are always output in ASCII format regardless of the specified output format. Following the query response, the output format returns to the specified type. The output format does not affect the memory format specified by the MFORMAT command.
- When using the SINT or DINT output formats, the multimeter applies a scale factor to each reading. This scale factor is based on the present measurement function, range, A/D setting, and enabled math operations. Therefore, ensure that the multimeter's configuration is the same when retrieving the scale factor (ISCALE? command) as it was when the readings were made.
- You should not use the SINT or DINT output or memory format for frequency or period measurements when a real-time or post-process math function is enabled (except STAT or PFAIL) or when autorange is enabled.

- **Query command:** The OFORMAT? query command returns the present output format mode. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** END, ISCALE?, MFORMAT, QFORMAT

Examples

SINT format

The following program outputs 10 readings in SINT format, retrieves the scale factor, and multiplies the scale factor times each reading.

```

10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 INTEGER Num_readings !DECLARE VARIABLE
30 INTEGER Int_rdgs (1:10) BUFFER!CREATE INTEGER BUFFER ARRAY
40 REAL Rdgs(1:10) !CREATE REAL ARRAY
50 Num_readings=10 !NUMBER OF READINGS = 10
60 ASSIGN @Dvm TO 722 !ASSIGN MULTIMETER ADDRESS
70 ASSIGN @Int_rdgs TO BUFFER Int_rdgs(*) !ASSIGN BUFFER I/O PATH NAME
80 OUTPUT @Dvm;"PRESET NORM;OFORMAT SINT;NPLC 0;NRDGS ";Num_readings
85 !TARM AUTO, TRIG SYN, SINT OUTPUT FORMAT, MIN. INTEGRATION TIME
90 TRANSFER @Dvm TO @Int_rdgs;WAIT !SYN EVENT, TRANSFER READINGS INTO
91 !INTEGER ARRAY; SINCE THE COMPUTER'S INTEGER FORMAT IS THE SAME AS
95 !SINT, NO DATA CONVERSION IS NECESSARY HERE (INTEGER ARRAY REQUIRED)
100 OUTPUT @Dvm;"ISCALE?" !QUERY SCALE FACTOR FOR SINT FORMAT
110 ENTER @Dvm;S !ENTER SCALE FACTOR
120 FOR I=1 TO Num_readings
130 Rdgs(I)=Int_rdgs(I) !CONVERT EACH INTEGER READING TO REAL
135 !FORMAT (NECESSARY TO PREVENT POSSIBLE INTEGER OVERFLOW ON NEXT
LINE)
140 R=ABS(Rdgs(I)) !USE ABSOLUTE VALUE TO CHECK FOR OVLD
150 IF R>=32767 THEN PRINT "OVLD" !IF OVLD, PRINT OVERLOAD MESSAGE
160 Rdgs(I)=Rdgs(I)*S !MULTIPLY READING TIMES SCALE FACTOR
170 Rdgs(I)=DROUND(Rdgs(I),4) !ROUND TO 4 DIGITS

```

```
180 NEXT I
```

```
190 END
```

DINT format

The following program is similar to the preceding program except that it takes 50 readings and transfers them to the computer using the DINT format.

```
10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
```

```
20 INTEGER Num_readings,I,J,K !DECLARE VARIABLES
```

```
30 Num_readings=50 !NUMBER OF READINGS = 50
```

```
40 ALLOCATE REAL Rdgs(1:Num_readings) !CREATE ARRAY FOR READINGS
```

```
50 ASSIGN @Dvm TO 722 !ASSIGN MULTIMETER ADDRESS
```

```
60 ASSIGN dBuffer TO BUFFER[4*Num_readings] !ASSIGN BUFFER I/O PATH NAME
```

```
70 OUTPUT @Dvm;"PRESET NORM;RANGE 10;OFORMAT DINT;NRDGS";Num_readings
```

```
75 !TARM AUTO, TRIG SYN, DCV 10 V RANGE, DINT OUTPUT FORMAT, NRDGS  
50,AUTO
```

```
80 TRANSFER @Dvm TO @Buffer;WAIT !SYN EVENT,TRANSFER READINGS
```

```
90 OUTPUT @Dvm; "ISCALE?" !QUERY SCALE FOR DINT
```

```
100 ENTER @Dvm; S !ENTER SCALE FACTOR
```

```
110 FOR I=1 TO Num_readings
```

```
120 ENTER @Buffer USING "#,w,w";J,K !ENTER ONE 16-BIT 2'S COMPLEMENT
```

```
121 !WORD INTO EACH VARIABLE J AND K (# = STATEMENT TERMINATION NOT
```

```
125 !REQUIRED; W= ENTER DATA AS 16-BIT 2'S COMPLEMENT INTEGER)
```

```
130 Rdgs(I)=(J*65536.+K+65536.*(K<0)) !CONVERT TO REAL NUMBER
```

```
140 R=ABS(Rdgs(I)) !USE ABSOLUTE VALUE TO CHECK FOR OVLD
```

```
150 IF R>2147483647 THEN PRINT "OVLD" !IF OVERLOAD OCCURRED, PRINT  
MESSAGE
```

```
160 Rdgs(I)=Rdgs(I)*S !APPLY SCALE FACTOR
```

```
170 Rdgs(I)=DROUND(Rdgs(I),8) !ROUND CONVERTED READING
```

```
180 PRINT Rdgs(I) !PRINT READINGS
```

```
190 NEXT I
```

```
200 END
```

SREAL format

The following program shows how to convert 10 readings output in the SREAL format.

```

10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 INTEGER Num_readings !DECLARE VARIABLE
30 Num_readings=10 !NUMBER OF READINGS = 10
40 ALLOCATE REAL Rdgs(1:Num_readings) !CREATE ARRAY FOR READINGS
50 ASSIGN @Dvm TO 722 !ASSIGN MULTIMETER ADDRESS
60 ASSIGN @Buffer TO BUFFER [4*Num_readings] !ASSIGN BUFFER I/O PATH
NAME
70 OUTPUT @Dvm;"PRESET NORM;OFORMAT SREAL;NRDGS";Num_readings
75 !TRIG SYN, SREAL OUTPUT FORMAT, 1 PLC, DCV AUTORANGE, 10 READINGS
80 TRANSFER @Dvm TO @Buffer;WAIT !SYN EVENT; TRANSFER READINGS
90 FOR I=1 TO Num_readings
100 ENTER @Buffer USING "#,B";A,B,C,D !ENTER ONE 8-BIT BYTE INTO
101 !EACH VARIABLE, (# =STATEMENT TERMINATION NOT REQUIRED, B = ENTER
ONE
105 !8-BIT BYTE AND INTERPRET AS AN INTEGER BETWEEN 0 AND 255)
110 S=1 !CONVERT READING FROM SREAL
120 IF A>127 THEN S=-1 !CONVERT READING FROM SREAL
130 IF A>127 THEN A=A-128 !CONVERT READING FROM SREAL
140 A=A*2- 127 !CONVERT READING FROM SREAL
150 IF B>127 THEN A=A+1 !CONVERT READING FROM SREAL
160 IF B<=127 THEN B=B+128 !CONVERT READING FROM SREAL
170 Rdgs(I)=S*(B*65536.+C*256.+D)*2^(A-23) !CONVERT READING FROM SREAL
180 Rdgs(I)=DROUND(Rdgs(I),7) !ROUND READING TO 7 DIGITS; YOU
181 !MUST DO THIS WITH SREAL TO ENSURE ANY OVLD VALUES ARE ROUNDED TO
185 !1.E+38 (WITHOUT ROUNDING, THE VALUE MAY BE SLIGHTLY LESS)
190 IF ABS(Rdgs(I))=1.E+38 THEN !IF OVERLOAD OCCURRED:
200 PRINT "Overload Occurred" !PRINT OVERLOAD MESSAGE
210 ELSE !IF NO OVERLOAD OCCURRED:

```

```

220 PRINT Rdgs(I) !PRINT READING
230 END IF
240 NEXT I
250 END

```

DREAL format

The following program uses the DREAL output format. Notice that no conversion is necessary using this format since DREAL is the same format that the controller uses as its internal data format (8-bytes/word).

```

10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 REAL Rdgs(1:10) BUFFER !CREATE BUFFER ARRAY
30 ASSIGN @Dvm TO 722 !ASSIGN MULTIMETER ADDRESS
40 ASSIGN @Rdgs TO BUFFER Rdgs(*) !ASSIGN BUFFER I/O PATH NAME
50 OUTPUT @Dvm;"PRESET NORM;NPLC 10;OFORMAT DREAL;NRDGS 10"
55 !TRIG SYN, 10 PLCS, DCV AUTORANGE, DREAL OUTPUT FORMAT, 10 RDGS/TRIG.
60 TRANSFER @Dvm TO @Rdgs;WAIT !SYN EVENT, TRANSFER READINGS
70 FOR I=1 TO 10
80 IF ABS(Rdgs(I))=1.E+38 THEN !IF OVERLOAD OCCURRED:
90 PRINT "OVERLOAD OCCURRED" !PRINT OVERLOAD MESSAGE
100 ELSE !IF NO OVERLOAD:
110 Rdgs(I)=DROUND(Rdgs(I),8) !ROUND READINGS
120 PRINT Rdgs(I) !PRINT READINGS
130 END IF
140 NEXT I
150 END

```

The preceding program used the TRANSFER statement to get readings from the multimeter. The following program uses the ENTER statement to transfer readings to the computer using the DREAL format. The ENTER statement is easier to use since no I/O path is necessary but is much slower than the TRANSFER statement. Also when using the ENTER statement, you must use the FORMAT OFF command to instruct the controller to use its internal data structure instead of ASCII.

```

10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT

```

```

20 Num_readings=20 !NUMBER OF READINGS = 20
30 ALLOCATE REAL Rdgs(1:Num_readings) !CREATE ARRAY FOR READINGS
40 ASSIGN @Dvm TO 722 !ASSIGN MULTIMETER ADDRESS
50 OUTPUT @Dvm;"PRESET NORM;OFORMAT DREAL;NPLC 10;NRDGS";Num_readings
55 !TRIG SYN, DCV AUTORANGE, DREAL OUTPUT FORMAT,10 PLC, 20 READINGS/
TRIG
60 ASSIGN @Dvm;FORMAT OFF !USE 8-BYTE/WORD DATA STRUCTURE
70 FOR I=1 TO Num_readings
80 ENTER @Dvm;Rdgs(I) !ENTER EACH READING
90 IF ABS(Rdgs(I))=1.E+38 THEN !IF OVERLOAD OCCURRED:
100 PRINT "OVERLOAD OCCURRED" !PRINT OVERLOAD MESSAGE
110 ELSE !IF NO OVERLOAD OCCURRED
120 Rdgs(I)=DROUND(Rdgs(I),8) !ROUND READINGS TO 8 DIGITS
130 PRINT Rdgs(I) !PRINT READINGS
140 END IF
150 NEXT I
160 END

```

OHM, OHMF

Refer to the **FUNC** command.

OPT?

Option query. Returns a response indicating the multimeter's installed options. The possible responses are:

- 0 = No installed options
- 1 = Extended Reading Memory Option

Syntax

OPT?

Remarks

- **Related commands:** QFORMAT

Example

```
10 OUTPUT 722;"OPT?" !QUERY INSTALLED OPTIONS
20 ENTER 722;A$ !ENTER RESPONSE
30 PRINT A$ !PRINT RESPONSE
40 END
```

PAUSE

Suspends subprogram execution. The subprogram can be resumed using the CONT command or by executing the GPIB Group Execute Trigger command.

Syntax

PAUSE

Remarks

- The PAUSE command is allowed only within a subprogram.
- Only one subprogram will be preserved in a suspended state. If a subprogram is paused and another is run which also becomes paused, the first will be terminated and the second will remain suspended.
- With the input buffer off (INBUF OFF command), the GPIB bus is normally held by the multimeter until a called subprogram is completely executed. If a PAUSE command is encountered in a subprogram, the GPIB bus is released immediately.
- Nested PAUSE commands are not allowed; that is, when a subprogram is called from another subprogram, the called subprogram cannot contain a PAUSE command.
- **Query command:** The PAUSE? query command returns a response indicating whether a subprogram is currently paused. The possible responses are YES (numeric query equiv. = 1) indicating a subprogram is paused, or NO (numeric query equiv. = 0).
- **Related commands:** CALL, COMPRESS, CONT, DELSUB, TRIGGER (GPIB command), SCRATCH, SUB, SUBEND

Example

```
10 OUTPUT 722;"SUB OHMAC1" !STORES SUBPROGRAM NAMED OHMAC1
20 OUTPUT 722;"PRESET NORM" !SUSPENDS TRIGGERING, PRESET
30 OUTPUT 722;"MEM FIFO" !ENABLES READING MEMORY, FIFO MODE
40 OUTPUT 722;"OHM" !SELECTS 2-WIRE OHMS MEASUREMENTS
50 OUTPUT 722;"NRDGS 5" !SELECTS 5 READINGS PER TRIGGER
60 OUTPUT 722;"TRIG SGL" !GENERATES A SINGLE TRIGGER
70 OUTPUT 722;"PAUSE" !SUSPENDS PROGRAM EXECUTION
80 OUTPUT 722;"ACV" !SELECTS AC VOLTAGE MEASUREMENTS
90 OUTPUT 722;"NRDGS 10" !SELECTS 10 READINGS PER TRIGGER
100 OUTPUT 722;"TRIG SGL" !GENERATES A SINGLE TRIGGER
110 OUTPUT 722;"SUBEND" !SIGNIFIES THE END OF THE SUBPROGRAM
120 END
```

When you call the above subprogram, the multimeter executes the subprogram line by line. Lines 20 through 60 cause the multimeter to make five 2-wire ohms readings and place them in reading memory. When line 70 is encountered, subprogram execution ceases. A subsequent CONT command or Group Execute Trigger resumes program execution. Lines 80 through 100 then cause the multimeter to make 10 AC voltage readings and place them in reading memory. When the subprogram is finished, a total of 15 readings are in memory. To call the above subprogram, send:

```
OUTPUT 722;"CALL OHMAC1"
```

After the five 2-wire ohms readings are complete, connect an AC voltage source to the multimeter. Subprogram execution is resumed by sending the CONT command or by executing (on the controller):

```
TRIGGER 7
```

PER

Period. Instructs the multimeter to measure the period of the input signal. You can specify whether the input signal is AC voltage (default), AC+DC voltage, AC current, or AC+DC current using the FSOURCE command.

Syntax

PER [*max._input*][,*%_resolution*]

max._input

The *max._input* parameter selects a fixed range or the autorange mode. The ranges correspond to the type of input signal specified in the FSOURCE command. That is, if ACV is the specified input signal, the *max._input* parameter specifies an AC voltage measurement range. To select a fixed range, you specify *max._input* as the absolute value (no negative numbers) of the expected peak value of the input signal. The multimeter then selects the proper range. Refer to the **FUNC** or **RANGE** command for tables showing the ranges available for each type of input signal.

To select the autorange mode, specify AUTO for *max._input* or default the parameter. In the autorange mode, the multimeter samples the input signal before each period reading and selects the proper range.

Power-on *max._input* = not applicable

Default *max._input* = AUTO

%_resolution

The *%_resolution* parameter specifies the digits of resolution and the gate time as shown below (*%_resolution* also affects the reading rate, refer to the **“Appendix A: Specifications”** on page 409 for more information).

<i>%_resolution</i> parameter	Selects gate time	Digits of resolution
.00001	1 s	7
.0001	100 ms	7
.001	10 ms	6
.01	1 ms	5
.1	100 μ s	4

Power-on *%_resolution* = not applicable.
 Default *%_resolution* = .00001.

Remarks

- The reading rate is the longer of 1 period of the input signal, the gate time, or the default reading time-out of 1.2 seconds.
- Period (and frequency) measurements are made using the level detection circuitry to determine when the input signal crosses a particular voltage on its positive or negative slope. (This is why you cannot use the LEVEL trigger or sample event or the LINE trigger event when making period or frequency measurements.) The power-on or default level triggering values select zero volts, positive slope. You can control the level triggering voltage and coupling using the LEVEL command. You can specify either the positive or negative slope using the SLOPE command.
- The leftmost digit, which is a half digit for most measurement functions, is a full digit (0 - 9) for period measurements.
- Readings made with autorange enabled take longer because the input signal is sampled (to determine the proper range) between readings.
- For period (and frequency) measurements, an overload indication means the voltage or current amplitude is too great for the specified measurement range. It does not mean the applied period (or frequency) is too great to be measured.
- **Related commands:** ACBAND, FREQ, FSOURCE, FUNC, RES

Example

```
10 OUTPUT 722;"FSOURCE ACI" !SELECTS AC CURRENT AS INPUT SOURCE
20 OUTPUT 722;"PER .01" !SELECTS PERIOD MEASUREMENTS, 10 mA RANGE
30 END
```

PRESET

Configures the multimeter to one of three predefined states.

Syntax

PRESET [*type*]

type

Specifies the NORM, FAST, or DIG preset state (the numeric query equivalents of these parameters are 1, 0, and 2, respectively).

Power-on *type* = not applicable.

Default *type* = NORM.

NORM

PRESET NORM is similar to RESET but optimizes the multimeter for remote operation. Executing PRESET NORM executes the following commands:

`ACBAND 20,2E+6MEM OFF (last memory operation set to FIFO)`

`AZERO ONMFORMAT SREAL`

`BEEP ONMMATH OFF`

`DCV AUTONDIG 6`

`DELAY -1NPLC 1`

`DISP ONNRDGS 1,AUTO`

`FIXEDZ OFF OCOMP OFF`

`FSOURCE ACVOFORMAT ASCII`

`INBUF OFFTARM AUTO`

`LOCK OFFTIMER 1`

`MATH OFFTRIG SYN`

All math registers set to 0 except:

`DEGREE = 20`

`PERC = 1`

`REF = 1`

`RES = 50`

`SCALE = 1`

FAST

PRESET FAST configures the multimeter for fast readings, fast transfer to memory, and fast transfer from memory to GPIB. (Refer to [Increasing the Reading Rate](#) in [Chapter 4](#) for more information on fast measurements.) Executing PRESET FAST executes the commands shown under PRESET NORM with the following exceptions:

DCV 10

AZERO OFF

DISP OFF

MFORMAT DINT

OFORMAT DINT

TARM SYN

TRIG AUTO

DIG

PRESET DIG configures the multimeter for DCV digitizing (DCV digitizing is discussed in [Chapter 5](#)). Executing PRESET DIG executes the commands shown under PRESET NORM with the following exceptions:

DCV 10

AZERO OFF

DELAY 0

DISP OFF

TARM HOLD

TRIG LEVEL

LEVEL 0,AC

NRDGS 256,TIMER

TIMER 20E-6

APER 3E-6

MFORMAT SINT

OFORMAT SINT

Remarks

- **Related commands:** RESET

Examples

OUTPUT 722;"PRESET NORM" !CONFIGURES FOR REMOTE OPERATION

OUTPUT 722;"PRESET FAST" !CONFIGURES FOR FAST READINGS/TRANSFER

OUTPUT 722;"PRESET DIG" !CONFIGURES FOR FAST DCV DIGITIZING

PURGE

Purge state. Removes a single stored state from memory.

Syntax

PURGE *name*

name

State name. A state name may contain up to 10 characters. The name can be alpha, alphanumeric, or an integer in the range of 0 to 127. Refer to the **SSTATE** command for details.

Power-on *name* = none.

Default *name* = none; parameter required.

Remarks

- To delete all stored states, use the SCRATCH command.
- **Related commands:** DELSUB, SCRATCH

Example

OUTPUT 722; "PURGE A2"!PURGES STORED STATE A2

QFORMAT

Query format. Designates whether query responses contain numeric or alpha characters (whenever possible), and whether command headers are returned.

Syntax

QFORMAT [*type*]

format

The *type* parameter choices are:

<i>type</i> parameter	Numeric query equiv.	Description
NUM	0	Query responses sent to either GPIB or the display are numeric only (whenever possible) with no headers
NORM	1	Query responses sent to the GPIB are numeric only (whenever possible) with no headers; query responses sent to the display contain alpha headers and alpha responses (whenever possible)
ALPHA		Query responses sent to either GPIB or the display contain an alpha header and an alpha response (whenever possible)

Power-on *type* = NORM.

Default *type* = NORM.

- The *numeric query equivalents* for alpha parameters are shown under each applicable command in this chapter. Some query commands such as DEFKEY? will always return alpha characters regardless of the specified QFORMAT. Similarly, some query commands such as NDIG? will always return a numeric response.
- When you execute a query command from the multimeter's front panel, the result goes to the display only. When you execute a query command from the controller, the result goes to the multimeter's output buffer only. Query results are returned in ASCII format, after which the output format returns to the previously specified type (ASCII, SINT, etc.).

- **Query command:** The QFORMAT? query command returns the present query format. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** All query commands, OFORMAT

Examples

NORM

```
10 OUTPUT 722;"QFORMAT NORM"
20 OUTPUT 722;"ARANGE?"
30 ENTER 722;A
40 PRINT A
50 END
```

Typical response: 1

NUM

```
10 OUTPUT 722;"QFORMAT NUM"
20 OUTPUT 722;"ARANGE?"
30 ENTER 722;A
40 PRINT A
50 END
```

Typical response: 1

ALPHA

```
10 OUTPUT 722;"QFORMAT ALPHA"
20 OUTPUT 722;"ARANGE?"
30 ENTER 722;A$
40 PRINT A$
50 END
```

Typical response: ARANGE ON

R

R is an abbreviation for the RANGE command.

Syntax

R [*max._input*][, *%_resolution*]

Refer to the **RANGE** command for more information.

RANGE

The RANGE command allows you to select a measurement range or the autorange mode.

Syntax

RANGE [*max._input*][, *%_resolution*]

max._input

The *max._input* parameter selects a fixed range or the autorange mode. To select a fixed range, you specify the *max._input* as the absolute value (no negative numbers) of the maximum expected amplitude of the input signal. The multimeter then selects the correct range. To select the autorange mode, specify AUTO for *max._input* or default the parameter. In the autorange mode, the multimeter samples the input signal before each reading and selects the appropriate range.

- The following tables show the *max._input* parameters and the ranges they select for each measurement function.

For DCV:

<i>max._input</i> parameter	Selects range	Full scale
–1 or AUTO	Autorange	
0 to .12	100 mV	120 mV
>.12 to 1.2	1 V	1.2V
>1.2 to 12	10 V	12 V
>12 to 120	100 V	120 V
>120 to 1E3	1000 V	1050 V

For ACV or ACDCV:

<i>max._input</i> parameter	Selects range	Full scale
–1 or AUTO	Autorange	
0 to .012	10 mV	12mV
>.012 to .12	100 mV	120 mV
>.12 to 1.2	1V	1.2V
>1.2 to 12	10 V	12V
>12 to 120	100 V	120 V
>120 to 1E3	1000 V	1050 V

For OHM or OHMF:

<i>max._input</i> parameter	Selects range	Full scale
–1 or AUTO	Autorange	
0 to 12	10 Ω	12 Ω
>12 to 120	100 Ω	120k Ω
>120 to 1.2E3	1k Ω	1.2k Ω
>1.2E3 to 1.2E4	10k Ω	12k Ω
>1.2E4 1.2E5	100k Ω	120k Ω
>1.2E5 to 1.2E6	1M Ω	1.20M Ω
>1.2E6 to 1.2E7	10M Ω	12M Ω
>1.2E7 1.2E8	100M Ω	120M Ω
>1.2E8 1.2E9	1G Ω	1.2G Ω

For DCI:

<i>max._input</i> parameter	Selects range	Full scale
–1 or AUTO	Autorange	
0 to .12E-6	.1 μ A	.12 μ A
>.12E-6 to 1.2E-6	1 μ A	1.2 μ A
>1.2E-6 to 12E-6	10 μ A	12 μ A
>12E-6 to 120E-6	100 μ A	120 μ A
>120E-6 to 1.2E-3	1 mA	1.2 mA
>1.2E-3 to 12E-3	10 mA	12 mA
>12E-3 to 120E-3	100 mA	120 mA
>120E-3 to 1.2	1 A	1.05 A

For ACI or ACDCI:

<i>max._input</i> parameter	Selects range	Full scale
-1 or AUTO	Autorange	
0 to .120E-6	100 μ A	120 μ A
>120E-6 to 1.2E-3	1mA	1.2mA
>1.2E-3 to 12E-3	10 mA	12mA
>12E-3 to 120E-3	100 mA	120 mA
>120E-3 to 1.2	1A	1.05A

For SSAC or SSDC:

<i>max._input</i> parameter	Selects range	Full scale
0 to .012	10 mV	12mV
>.012 to .120	100 mV	120 mV
>.120 to 1.2	1V	1.2V
>1.2 to 12	10 V	12V
>12 to 120	100 V	120 V
>120 to 1E3	1000 V	1050 V

For DSAC or DSDC:

<i>max._input</i> parameter	Selects range	Full scale	
		SINT format	DINT format
0 to .012	10 mV	12mV	50 mV
>.012 to .120	100 mV	120 mV	500 mV
>.120 to 1.2	1V	1.2V	5.0 V
>1.2 to 12	10 V	12V	50 V
>12 to 120	100 V	120 V	500 V
>120 to 1E3	1000 V	1050 V	1050 V

Power-on *max._input* = AUTO.Default *max._input* = AUTO.**%_resolution**

For all functions except the digitizing functions (DSAC, DSDC, SSAC, and SSDC), the *%_resolution* parameter specifies the measurement resolution. (The multimeter ignores *%_resolution* when included with a digitizing command.) For frequency and period measurements, you specify *%_resolution* as the number of digits to be resolved. For the remaining measurement functions (DCV, ACV, ACDCV, OHM, OHMF, DCI, and ACI), you specify the *%_resolution* as a percentage of the *max._input* parameter. The multimeter then multiplies *%_resolution* by the *max._input* to determine the measurement's resolution.

For example, suppose your maximum expected input is 10 V and you want 1 mV of resolution. To determine *%_resolution*, use the equation:

$$\%\_resolution = (\text{actual resolution}/\text{maximum input}) \times 100$$

In this example, the equation evaluates to:

$$\%\_resolution = (.001/10) \times 100 = .0001 \times 100 = .01$$

NOTE

When using autorange, the multimeter multiplies the *%_resolution* parameter times the full scale reading of the selected range. The result is the minimum resolution. The multimeter always gives you at least the minimum resolution and, in many cases, gives you additional digits of resolution.

Power-on *%_resolution* = none. At power-on, the resolution is determined by the NPLC command which produces 8 ½ digits. (The power-on value for NDIG masks 1 display digit causing the multimeter to display only 7 ½ digits. You can use the NDIG 8 command to display all 8 ½ digits; refer to the **NDIG** command for details.)

Default *%_resolution*:

For frequency or period measurements, the default *%_resolution* is .00001 which selects a gate time of 1 s and 7 digits of resolution.

For sampled ACV or ACDCV, the default *%_resolution* is 0.01% for SETACV SYNC, or 0.4% for SETACV RNDM.

For all other measurement functions, the default resolution time is determined by the present integration time.

Remarks

- **Query command:** The RANGE? query command returns the present measurement range. (RANGE? does not indicate the autorange mode; use the ARANGE? command to determine the autorange mode.) Refer to **Query commands** near the front of this chapter for more information.
- **Related commands:** ARANGE, FUNC, R

Examples

In the following program, line 10 allows *%_resolution* in line 30 to control the resolution. The resolution specified by line 30 is 10 mΩ.

```
10 OUTPUT 722;"NPLC 0" !SETS PLCS TO MINIMUM
20 OUTPUT 722;"OHM" !SELECTS 2-WIRE OHMS
30 OUTPUT 722;"RANGE 800,.00125" !SELECTS 800 Ω MAX, 10 mΩ
40 END!RESOLUTION
```

RATIO

The RATIO command instructs the multimeter to measure a DC reference voltage applied to the Ω Sense terminals and a signal voltage applied to the Input terminals. The multimeter then computes the ratio as:

Ratio =
$$\frac{\text{Signal Voltage}}{\text{DC Reference Voltage}}$$

Syntax

RATIO [*control*]

control

control parameter	Numeric query equiv.	Description
OFF	0	Disables ratio measurements
ON	1	Enables ratio measurements using the present measurement function (DCV, ACV, or ACDCV)

Power-on *control* = OFF.
Default *control* = ON.

Remarks

- The Ω Sense LO and the Input LO terminals must have a common reference and cannot have a voltage difference >0.25 V.
- The signal voltage can be measured using the DCV, ACV, or ACDCV measurement function. (For ACV or ACDCV, any of the three measurement methods ANA, RNDM, or SYNC may be used.) The multimeter always uses DCV for the reference voltage measurement. The measurable reference

voltage range is ± 12 VDC (autorange only). To specify ratio measurements, you first select the measurement function (and the measurement method for ACV or ACDCV) and then enable ratio measurements with the RATIO command (see example below).

- **Query command:** The RATIO? query command returns the present ratio mode. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** ACDCV, ACV, DCV, SETACV

Example

```
10 OUTPUT 722;"PRESET NORM" !SUSPEND READINGS,NRDGS=1
20 OUTPUT 722;"ACV" !SELECT AC VOLTAGE MEASUREMENTS
30 OUTPUT 722;"SETACV SYNC" !SYNCHRONOUS ACV MEASUREMENTS
40 OUTPUT 722;"RATIO ON" !ENABLE RATIO MEASUREMENTS
50 OUTPUT 722;"TRIG SGL" !TRIGGER MEASUREMENT
60 ENTER 722;A !ENTER RATIO
70 PRINT A !PRINT RATIO
80 END
```

RES

Resolution. Specifies reading resolution.

Syntax

RES [%_resolution]

%_resolution

For frequency and period measurements, the *%_resolution* parameter specifies the digits of resolution and the gate time as shown below. (*%_resolution* also affects the reading rate. Refer to the ["Appendix A: Specifications"](#) on page 409 for more information.) If you default the *%_resolution* parameter for frequency or period measurements, the multimeter uses .00001.

<i>%_resolution parameter</i>	Selects gate time	Digits of resolution
.00001	1 s	7
.0001	100 ms	7
.001	10 ms	6
.01	1 ms	5
.1	100 μ s	4

For sampled ACV or ACDCV, random sampling (SETACV RNDM) has a fixed resolution of 4.5 digits that cannot be changed. For synchronous sampling (SETACV SYNC), a *%_resolution* parameter of 0.001 = 7.5 digits; 0.01 = 6.5 digits; 0.1 = 5.5 digits; and 1 = 4.5 digits.

For all other functions (except DSAC, DSDC, SSAC, and SSDC): *%_resolution* is ignored for these functions), the multimeter multiplies *%_resolution* times the present measurement range (1 V, 10 V, 100 V, etc.) to determine the resolution. To compute the *%_resolution* parameter, use the equation:

$$\%_resolution = (\text{actual resolution}/\text{range}) \times 100.$$

For example, suppose you are measuring DC voltage on the 10 V range and you want 100 μ V of resolution. The equation evaluates to:

$$\%_resolution = (.0001 / 10) \times 100 = .001$$

Power-on *%_resolution* none. At power-on, the resolution is determined by the NPLC command which produces 8 ½ digits. (The power-on value for NDIG masks 1 display digit causing the multimeter to display only 7 ½ digits. You can use the NDIG 8 command to display all 8 ½ digits.)

Default *%_resolution*:

For frequency or period measurements, the default *%_resolution* is .00001 which selects a gate time of 1 s and 7 digits of resolution.

For sampled ACV or ACDCV, the default *%_resolution* is 0.01% for SETACV SYNC or 0.4% for SETACV RNDM.

For all other measurement functions, the default resolution is determined by the present integration time.

Remarks

- For analog measurements, the *%_resolution* parameter of the RES command operates slightly differently than the *%_resolution* parameter of a function command (FUNC, ACV, DCV, etc.) or the RANGE command. When used with the RES command, *%_resolution* is multiplied times the range to determine the actual resolution. When used with a function command or the RANGE command, *%_resolution* is multiplied times that command's *max._input* parameter. The *max._input* parameter may or may not be the value of a measurement range.
- **Query command:** The RES? query command returns the specified *%_resolution*. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** ACDCI, ACDCV, ACI, ACV, APER, DCI, DCV, FREQ, FUNC, NPLC, OHM, OHMF, PER, RANGE

Examples

In the following program, line 10 allows *%_resolution* in line 30 to control the resolution.

```
10 OUTPUT 722;"NPLC 0" !SETS PLCS TO MINIMUM
20 OUTPUT 722;"DCV 6," !SELECTS DC VOLTS, 10 V RANGE
30 OUTPUT 722;"RES .001" !100 µV OF RESOLUTION ON THE 10 V RANGE
40 END
```

In the following program, line 10 sets the number of PLCs to 1000. This corresponds to maximum resolution (7.5 digits) and prevents the RES command in line 30 from affecting the measurement. The requested resolution in line 30 is 10 mΩ. However, because of line 10, the actual resolution is 100 µΩ.

```
10 OUTPUT 722;"NPLC 1000" !SETS PLCS TO MAXIMUM
20 OUTPUT 722;"OHM 1E3 !SELECTS 2-WIRE OHMS, 1 kΩ RANGE
30 OUTPUT 722;"RES .001 !REQUESTS 10 mΩ RESOLUTION
40 END
```

RESET

Allows you to set the multimeter to the power-on state without cycling power.

Syntax

RESET

Remarks

- The RESET command does the following:

Aborts readings in process.

Clears error and auxiliary error registers.

Clears the status register except the Power-on SRQ bit (bit 3).

Clears reading memory.

In addition, the RESET command also executes these commands:

ACBAND 20,2E6	LOCK OFF
AZERO ON	MATH OFF
DCV AUTO	MEM OFF (last memory operation set to FIFO)
DEFEAT OFF	MFORMAT SREAL
DELAY -1	MMATH OFF
DISP ON	NDIG 7
EMASK 32767 (all enabled)	NPLC 10
END OFF	NRDGS 1,AUTO
EXTOUT ICOMP,NEG	OCOMP OFF
FIXEDZ OFF	OFORMAT ASCII QFORMAT NORM
FSOURCE ACV	RATIO OFF
INBUF OFF	RQS 0
LEVEL 0,AC	SETACV ANA
LFILTER OFF	SLOPE POS
LFREQ (line frequency rounded to 50 or 60 Hz)	SSRC LEVEL,AUTO

ALL math registers set to 0 except:

```

DEGREE = 20      REF = 1
SCALE   = 1      RES = 50
PERC    = 1

```

- Although RESET can be used from remote, it is intended primarily for front panel use. RESET configures the multimeter to a good starting point for local operation. Executing the RESET command from the alphabetic menu resets the multimeter as shown above. Pressing the shifted front panel **Reset** key, however, has the same effect as cycling the multimeter's power. This stores the present state as state 0, any compressed subprograms are destroyed, stored readings are destroyed, the power-on SRQ bit is set in the status register, and the power-on sequence is performed.
- When attempting to send the RESET command from remote, it is possible that the multimeter is busy or the GPIB bus is being held. In either case, the multimeter will not respond immediately to the remote RESET command. For this reason, you should send the GPIB device clear command before you send the multimeter's RESET command. This is shown in the example below.
- **Related commands:** PRESET

Example

```

10 CLEAR 722          !CLEARS THE MULTIMETER IMMEDIATELY
20 OUTPUT 722;"RESET" !RESETS THE MULTIMETER
30 END

```


REV?

Revision query. Returns two numbers separated by a comma. The first number is the multimeter's master processor firmware revision. The second number is the slave processor firmware revision.

Syntax

REV?

Example

```
10 OUTPUT 722; "REV?" !READ FIRMWARE REVISION NUMBERS
20 ENTER 722; A, B !ENTER NUMBERS
30 PRINT A, B !PRINT NUMBERS
40 END
```

RMATH

Recall math. Reads and returns the contents of a math register.

Syntax

RMATH [*register*]

register

The *register* parameter choices are:

<i>register</i> parameter	Numeric query equiv.	Register contents
DEGREE	1	Time constant for FILTER and RMS
LOWER	2	Smallest reading in STATS
MAX	3	Upper Limit for PFAIL operation
MEAN	4	Average of readings in STATS
MIN	5	Lower limit for PFAIL
NSAMP	6	Number of samples in STATS

<i>register parameter</i>	<i>Numeric query equiv.</i>	<i>Register contents</i>
OFFSET	7	Subtrahend in NULL and SCALE operations
PERC	8	% value for PERC operation
REF	9	Reference value for DB operation
RES	10	Reference impedance for DBM operation
SCALE	11	Divisor in the SCALE operation
SDEV	12	Standard deviation in STATS
UPPER	13	Largest reading in STATS
HIRES	14	Not used by any math operation (extra register)
PFAILNUM	15	The number of reading that passed PFAIL before a failure was encountered

Power-on *register* = none.
Default *register* = DEGREE.

Remarks

- Math register contents are always output in the ASCII output format regardless of the specified output format. Afterwards, the output format returns to that previously specified (SINT, DINT, SREAL, DREAL, or ASCII).
- **Related commands:** MATH, MMATH, SMATH

Example

```

10 OUTPUT 722;"TRIG HOLD" !SUSPENDS TRIGGERING
20 OUTPUT 722;"MEM FIFO" !ENABLE READING MEMORY, FIFO MODE
30 OUTPUT 722;"NRDGS 10" !TEN READINGS PER TRIGGER
40 OUTPUT 722;"DCV 3" !DC VOLTAGE, 10 V RANGE
50 OUTPUT 722;"MATH STAT" !ENABLES STATISTICS MATH OPERATION
60 OUTPUT 722;"TRIG SGL" !TRIGGERS THE MULTIMETER ONCE
70 OUTPUT 722;"RMATH SDEV" !READS STANDARD DEVIATION
80 ENTER 722;A !ENTERS STANDARD DEVIATION

```

```

90 PRINT A !PRINTS STANDARD DEVIATION
100 END

```

RMEM

Recall memory. Reads and returns the value of a reading or group of readings stored in reading memory. RMEM leaves stored readings intact (not cleared from memory).

Syntax

RMEM [*first*][,*count*][,*record*]

first

Designates the beginning reading.

Power-on *first* = none.

Default *first* = 1.

count

Designates the number of readings to be recalled, starting with *first*.

Power-on *count* = none.

Default *count* = 1.

record

Designates the record from which to recall readings. Records correspond to the number of readings specified by the NRDGS command. For example, if NRDGS specifies three readings per trigger, each record will contain three readings.

Power-on *record* = none.

Default *record* = 1.

Remarks

- The RMEM command automatically shuts off reading memory (MEM OFF). This means all previously stored readings remain intact and new readings are not stored. You can re-enable reading memory without destroying any stored readings using the MEM CONT command.
- The multimeter assigns a number to each reading in reading memory. The most recent reading is assigned the lowest number (1) and the oldest reading

has the highest number. Numbers are always assigned in this manner regardless of whether you're using the FIFO or LIFO mode. Records are also numbered in this manner—the most recent record is record number 1.

- When you execute the RMEM command from the front panel, readings are copied, one at a time, to the display. After viewing the first reading, you can view others by using the up or down arrow key. Use the left and right arrow keys to view the reading number (left side of display) and the reading (right side of display).
- In addition to the RMEM command, you can also recall readings using the “implied read.” Refer to [Recalling readings](#) in [Chapter 4](#) for more information.
- **Related commands:** MCOUNT?, MEM, MFORMAT, MSIZE, NRDGS

Example

```
10 OUTPUT 722;"TARM HOLD" !SUSPENDS TRIGGERING
20 OUTPUT 722;"DCV" !DC VOLTAGE MEASUREMENTS
30 OUTPUT 722)"TRIG AUTO" !AUTOMATIC TRIGGERING
40 OUTPUT 722;"NRDGS 3 ,AUTO" !3 READINGS PER SAMPLE EVENT (AUTO)
50 OUTPUT 722;"MEM FIFO" !ENABLES READING MEMORY, FIFO MODE
60 OUTPUT 722;"TARM SGL, 10" !10 GROUPS OF READINGS
70 OUTPUT 722;"RMEM 1,3,6" !READS 1ST - 3RD READINGS of 6TH GROUP
80 ENTER 722;A,B,C !ENTERS READINGS INTO A, B, & C VARIABLES
90 PRINT A,B,C !PRINTS READINGS
100 END
```

RQS

Request service. Enables one or more status register conditions. When a condition is enabled and that condition occurs, it sets the GPIB SRQ line true.

Syntax

RQS [*value*]

value

You enable a condition by specifying its decimal weight as the value parameter. For more than one condition, specify the sum of the weights. The conditions and their weights are:

Decimal weight	Bit number	Enables condition
1	0	Program Memory Execution Completed
2	1	Hi or Lo Limit Exceeded
4	2	SRQ Command Executed
8	3	Power-On SRQ
16	4	Ready for Instructions
32	5	Error (Consult Error Register)
64	6	Service Requested (you cannot disable this bit)
128	7	Data Available

Power-on *value*: If Power-On SRQ was enabled when power was removed, value = 8; otherwise, value = 0.

Default *value* = 0 (no conditions enabled).

Remarks

- You can control the errors that will set bit 5 with the EMASK command.
- The power-on SRQ bit is stored in continuous memory. All other bits are cleared at power-on.

- **Query command:** The RQS? query command returns the weighted sum of all enabled bits in the status register.
- **Related commands:** CSB, SPOLL (GPIB command), STB?

Examples

OUTPUT 722;"RPS 4" !ENABLES THE FRONT PANEL SRQ CONDITION

OUTPUT 722;"RQS 40" !ENABLES POWER-ON SRQ (8) & !ERROR (32) CONDITIONS

OUTPUT 722;"RQS 255" !ENABLES ALL CONDITIONS

OUTPUT 722;"RQS 0" !DISABLES ALL CONDITIONS

RSTATE

Recall state. Recalls a stored state from memory and configures the multimeter to that state. States are stored using the SSTATE command.

Syntax

RSTATE [*name*]

name

State name. A state name may contain up to 10 characters. The name can be alpha, alphanumeric, or an integer in the range of 0 to 127. Refer to the **SSTATE** command for details.

Power-on *name* = none.

Default *name* = 0.

Remarks

- Whenever the multimeter's power is removed, the present state is stored in state 0. After a power failure, the multimeter can be configured to its previous state by executing RSTATE 0.
- If the NULL real-time math operation was enabled in a stored state, after recalling the state, the first reading is placed in the OFFSET register (refer to **NULL** in **Chapter 4** for more information).
- From the front panel, you can review the names of all stored states by pressing the **Recall State** key and by using the up and down arrow keys. When you have found the desired state, press the **Enter** key to recall that state.

- **Related commands:** MSIZE, PURGE, SCRATCH, SSTATE

Example

```
OUTPUT 722; "RSTATE B2" !RECALLS STORED STATE NAMED B2
```

SCAL

This is a calibration command. Refer to the *3458A Calibration Manual* for details.

SCRATCH

Clears all subprograms and stored states from memory.

Syntax

```
SCRATCH
```

Remarks

- Individual subprograms can be cleared with the DELSUB command. Individual states can be cleared with the PURGE command.
- **Related commands:** DELSUB, PURGE, RSTATE, SSTATE, SUB

Example

```
OUTPUT 722;"SCRATCH" !CLEARS ALL SUBPROGRAMS AND STORED STATES
```

SECURE

Security code. Allows the person responsible for calibration to enter a security code to prevent accidental or unauthorized calibration or autocalibration (autocal). (Refer to the **ACAL** command for details on autocal.)

Syntax

```
SECURE old_code, new_code[,acal_secure]
```

old_code

This is the multimeter's previous security code. The multimeter is shipped from the factory with its security code set to 3458A.

new_code

This is the new security code. The code is an integer from -2.1E9 to 2.1E9. If the number specified is not an integer, the multimeter rounds it to an integer value.

acal_secure

Allows you to secure autocalibration. The choices are:

<i>acal_secure</i> parameter	Numeric query equiv.	Description
OFF	0	Disables autocal security; no code required for autocal
ON	1	Enables autocal security; the security code is required to perform autocal (see ACAL for example).

Power-on *acal_secure* = Previously specified value (ON is the factory setting).
Default *acal_secure* = OFF.

Remarks

- Specifying 0 for the *new_code* disables the security feature making it no longer necessary to enter the security code to perform a calibration or autocal.
- The front panel's **Last Entry** key will not display the codes used in a previously executed SECURE command.
- **Related commands:** ACAL, CAL, CALNUM?, CALSTR, SCAL

Examples

Changing the code

```
OUTPUT 722;"SECURE 3458A,4448,0 n" !CHANGE FACTORY SECURITY CODE TO  
4448,  
!ENABLE AUTOCAL SECURITY
```

Disabling security

```
OUTPUT 722;"SECURE 3458A,0" !DISABLES SECURITY FOR CALIBRATION AND  
AUTOCAL
```


SETACV

Set ACV. Selects the RMS conversion technique to be used for AC or AC+DC voltage measurements.

Syntax

SETACV [*type*]

type

The *type* parameter is used to select the measurement method: analog, random sampling, or synchronous sampling. The parameters are:

<i>type</i> parameter	Numeric query equiv.	Description
ANA	1	Analog RMS conversion
RNDM	2	Random sampling conversion
SYNC	3	Synchronous sampling conversion

Power-on *type* = ANA.

Default *type* = ANA.

Remarks

- Bandwidth limitations vary with the conversion technique selected. See the [“Appendix A: Specifications”](#) on page 409 for details.
- **Query command:** The SETACV? query command returns the present AC measurement method. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** ACBAND, ACDCV, ACV, FUNC, SSR

Example

```
10 OUTPUT 722; "SETACV SYNC" !SPECIFIES SYNCHRONOUS SAMPLING (DC
COUPLED)
20 OUTPUT 722;"ACDCV" !SELECTS AC+DC VOLTAGE MEASUREMENTS
30 END
```

SLOPE

SLOPE is used in conjunction with the LEVEL command and specifies which slope of the signal will be used by the level-detection circuitry.

Syntax

SLOPE [*slope*]

slope

Selects the positive-going or negative-going slope of the input signal for use by the level detection circuitry. The choices are:

<i>slope</i> Parameter	Numeric query equiv.	Description
NEG	0	Selects negative-going slope
POS	1	Selects positive-going slope

Power-on *slope* = POS.

Default *slope* = POS.

Remarks

- **Query command:** The SLOPE? query command returns the present slope. Refer to **Query commands** near the front of this chapter for more information.
- **Related commands:** LEVEL, LFILTER, NRDGS, SSRG, TRIG

Example

```
OUTPUT 722;"SLOPE POS" !SELECTS THE POSITIVE GOING SLOPE FOR  
!LEVEL DETECTION
```

SMATH

Store math. Places a number in a math register.

Syntax

SMATH [*register*][,*number*]

register

The registers that can be written to are:

<i>register parameter</i>	Numeric query equiv.	Register contents	Power-on value
DEGREE	1	Time constant for FILTER and RMS	20
LOWER	2	Smallest reading in STATS	0
MAX	3	Upper limit for PFAIL operation	0
MEAN	4	Average of readings in STATS	0
MIN	5	Lower limit for PFAIL	0
NSAMP	6	Number of samples in STATS	0
OFFSET	7	Subtrahend in NULL and SCALE operations	0
PERC	8	% value for PERC operation	1
REF	9	Reference value for DB operation	1
RES	10	Reference impedance for DBM operation	50
SCALE	11	Divisor in the SCALE operation	1
UPPER	13	Largest reading in STATS	0
HIRES	14	Not used by any math operation	0
PFAILNUM	15	The number of readings that passed PFAIL before a failure was encountered	0

Default *register* = DEGREE.

Power-on *register* = see above listing.

number

The *number* parameter is the value to be placed in the register.

Default *number* = last reading.

Power-on *number* = see above listing.

Remarks

- You can use the SMATH command to place a number into one of the registers that store readings (UPPER, LOWER, etc.); however, that value will be replaced with a reading if the corresponding math function is enabled (e.g. STATS).
- You cannot use -1 (minus 1) to default the *number* parameter. If you specify -1, you will actually write -1 to the register.
- **Related commands:** MATH, MMATH, RMATH

Examples**OUTPUT 722;"SMATH 11,1E-3" !PLACES "1E-3" IN THE SCALE REGISTER**

In the following program, lines 10 and 20 configure for a resistance measurement. Line 30 triggers the resistance measurement. Line 40 defaults the *number* parameter causing the resistance reading to be stored in the RES register. Line 50 instructs the operator to connect the voltage source to the multimeter. Line 80 enables the DBM math operation. This program displays the power delivered to the resistance in DB (result of the DBM math operation).

```

10 OUTPUT 722;"PRESET NORM" !TARM AUTO, TRIG SYN, NRDGS 1,AUTO
20 OUTPUT 722;"OHM" !SELECTS 2-WIRE OHMS
30 OUTPUT 722;"TRIG SGL" !TRIGGERS ONCE
40 OUTPUT 722;"SMATH RES" !PLACES READING IN RES REGISTER
50 DISP "CONNECT SOURCE; PRESS CONT" !OPERATOR PROMPT
60 PAUSE !SUSPENDS PROGRAM EXECUTION
70 OUTPUT 722;"ACV" !SELECTS AC VOLTAGE
80 OUTPUT 722;"MATH DBM" !ENABLES DBM MATH OPERATION
90 OUTPUT 722;"TRIG AUTO" !TRIGGERS AUTOMATICALLY
100 END

```

SRQ

Service request. Sets bit 2 in the multimeter's status register. If bit 2 is enabled to assert SRQ (RQS 4 command), executing the SRQ command will set the GPIB SRQ line.

Syntax

SRQ

– **Related commands:** CSB, EXTOUT, RQS, SPOLL (GPIB command), STB?

Example

```
10 OUTPUT 722;"RQS 4" !ENABLE STATUS REGISTER BIT 2 TO ASSERT SRQ
20 OUTPUT 722;"SRQ" !SET BIT 2, ASSERT SRQ
30 END
```

SSAC, SSDC

Sub-sampling. Configures the multimeter for sub-sampled voltage measurements (digitizing). The SSAC function measures only the AC component of the input waveform. The SSDC function measures the combined AC and DC components of the waveform. Otherwise, the two functions are identical. The input signal must be periodic (repetitive) for sub-sampled measurements. Sub-sampled measurements use the track/hold circuit (2 nanoseconds aperture) and a wide bandwidth input. path (12 MHz bandwidth).

Syntax

SSAC [*max._input*] [, % *resolution*]

SSDC [*max._input*] [, % *resolution*]

max._input

Selects the measurement range (you cannot use autorange for sub-sampled measurements). To select a range, you specify *max._input* as the input signal's expected peak amplitude. The multimeter then selects the correct range. The following table shows the *max._input* parameters and the ranges they select.

<i>max._input</i> parameter	Selects range	Full scale
0 to .012	10 mV	12 mv
>.012 to .120	100 mV	120 mV
>.120 to 1.2	1 V	1.2 V
>1.2 to 12	10 V	12 V
>12 to 120	100 V	120 V
>120 to 1E3	1000 V	1050 V

Power-on *max._input* = not applicable.
 Default *max._input* = 10 V.

% resolution

Is ignored by the multimeter when used with the SSAC or SSDC command. This parameter is allowed in the command syntax to be consistent with the other function commands (FUNC, ACI, DCV, etc.).

Remarks

- Autozero and autorange do not function for sub-sampled measurements. Executing the SSAC or SSDC command suspends autozero and autorange operation.
- As with direct-sampling, you can specify a level triggering voltage up to 500% of the range. The required SINT format, however, cannot handle samples greater than 120% of range.
- If reading memory is disabled when you execute the SSAC or SSDC command, the multimeter automatically sets the output format to SINT (the memory format is not changed). Later, when you change to another measurement function, the output format returns to that previously specified. You must use the SINT output format when sub-sampling and outputting samples directly to the GPIB. You can, however, use any output format if the samples are first placed in reading memory (see next Remark). To do this, you should enable reading memory before executing the SSAC or SSDC command (executing SSAC or SSDC does not change the output format to SINT when reading memory is enabled).

- When sub-sampling with reading memory enabled, reading memory must be in FIFO mode, must be empty (executing MEM FIFO clears reading memory), and the memory format must be SINT prior to the occurrence of the trigger arm event. If not, the multimeter generates the SETTINGS CONFLICT error when the trigger arm event occurs and no samples are taken.
- For sub-sampling, the trigger event and the sample event are ignored (these events are discussed in [Chapter 4](#)). The only triggering events that apply to sub-sampling are the trigger arm event (TARM command) and the sync source event.
- In sub-sampling, samples are taken on more than one period of the input waveform. When the samples are sent directly to reading memory (MEM command), the multimeter automatically reconstructs the samples producing a composite waveform. When the samples are sent to the output buffer, the controller must use an algorithm to reconstruct the composite waveform. parameters for this algorithm are provided by the SSPARM? command.
- The *effective_interval* between samples and the total number of samples taken are specified by the SWEEP command. (You cannot use the NRDGS command for sub-sampling.) In sub-sampling, the multimeter will use as many periods of the input signal as necessary to achieve the specified *effective_interval*. The minimum *effective_interval* for sub-sampling is 10 nanoseconds. (Refer to [Sub-Sampling](#) in [Chapter 5](#) for a detailed description of the process.)
- **Related commands:** DSAC, DSDC, FUNC, ISCALE?, LEVEL, LFILTER, MEM FIFO, SLOPE, PRESET FAST, PRESET DIG, SSDC, SSPARM?, SSRC, SWEEP, TARM

Examples

In the following program, the sub-sampled data is sent to reading memory using the required SINT memory format. The multimeter places the samples in memory in the corrected order. The samples are then transferred to the controller using the DREAL output format (when placing sub-sampled data in reading memory first, you are not restricted to using the SINT output format).

```
10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 REAL Samp(1:200) BUFFER !CREATE BUFFER ARRAY
30 ASSIGN @Dvm TO 722 !ASSIGN MULTIMETER ADDRESS
40 ASSIGN @Samp TO BUFFER Samp(*) !ASSIGN BUFFER
50 OUTPUT @Dvm;"PRESET FAST" !TARM SYN, TRIG AUTO, DINT FORMATS
```

```

60 OUTPUT @Dvm; "MEM FIF0" !FIRST-IN-FIRST-OUT READING MEMORY
70 OUTPUT @Dvm; "MFORMAT SINT" !SINT MEMORY FORMAT
80 OUTPUT @Dvm; "OFORMAT DREAL" !DOUBLE REAL OUTPUT FORMAT
90 OUTPUT @Dvm; "SSDC 10" !SUB-SAMPLING, 10 V RANGE, DC-COUPLED
100 OUTPUT @Dvm; "SWEEP 5E - 6,200" !5  $\mu$ s EFF. INTERVAL, 200 SAMPLES
110 TRANSFER @Dvm TO @Samp;WAIT !TRANSFER SAMPLES TO CONTROLLER BUFFER
120 FOR I=1 TO 200
130 IF ABS(Samp(I))=1E+38 THEN !DETECT OVERLOAD
140 PRINT "Overload Occurred" !PRINT OVERLOAD MESSAGE
150 ELSE !IF NO OVERLOAD OCCURRED:
160 Samp(I)=DROUND(Samp(I),5) !ROUND TO 5 DIGITS
170 PRINT Samp(I) !PRINT EACH SAMPLE
180 END IF
190 NEXT I
200 END

```

In the program on the following page, the SSAC command is used to digitize a 10 kHz signal with a peak value of 5 V. The SWEEP command instructs the multimeter to take 1000 samples (Num_samples variable) with a 2 μ s *effective_interval* (Eff_int variable). The measurement uses the default level triggering for the sync source event (trigger from input signal, 0%, AC-coupling, positive slope). Line 120 generates a SYN event and transfers the samples directly to the computer. Lines 240 through 410 sort the sub-sampled data to produce the composite waveform. The composite waveform is stored in the Wave_form array.

```

10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 INTEGER Num_samples,Inc,I,J,K,L !DECLARE VARIABLES
30 Num_samples=1000 !DESIGNATE NUMBER OF SAMPLES
40 Eff_int=2.0E-6 !DESIGNATE EFFECTIVE INTERVAL
50 INTEGER Int_samp(1:1000) BUFFER !CREATE INTEGER BUFFER
60 ALLOCATE REAL Wave_form(1:Num_samples) !CREATE ARRAY FOR SORTED DATA
70 ALLOCATE REAL Samp(1:Num_samples) !CREATE ARRAY FOR SAMPLES
80 ASSIGN @Dvm TO 722 !ASSIGN MULTIMETER ADDRESS
90 ASSIGN @Int_samp TO BUFFER Int_samp(*) !ASSIGN BUFFER I/O PATH NAME

```



```

100 OUTPUT @Dvm;"PRESET FAST;LEVEL;SLOPE;SSRC LEVEL;SSDC 10"
101 !FAST OPERATION, TARM SYN, LEVEL SYNC SOURCE 0 V, POSITIVE SLOPE
105 !(DEFAULT VALUES) SUB-SAMPLING(SINT OUTPUT FORMAT), 10 V RANGE
110 OUTPUT @Dvm;"SWEEP ";Eff_int,Num_samples
115 !2  $\mu$ s EFFECTIVE INTERVAL, 1000 SAMPLES
120 TRANSFER @Dvm TO @Int_samp;WAIT !SYN EVENT,TRANSFER READINGS INTO
121 !INTEGER ARRAY; SINCE THE COMPUTER'S INTEGER FORMAT IS THE SAME AS
125 !SINT,NO DATA CONVERSION IS NECESSARY HERE (INTEGER ARRAY REQUIRED)
130 OUTPUT @Dvm;"ISCALE?" !QUERY SCALE FACTOR FOR SINT FORMAT
140 ENTER @Dvm; S !ENTER SCALE FACTOR
150 OUTPUT @Dvm;"SSPARM?" !QUERY SUB-SAMPLING PARAMETERS
160 ENTER @Dvm;N1,N2,N3 !ENTER SUB-SAMPLING PARAMETERS
170 FOR I=1 TO Num_samples
180 Samp(I)=Int_samp(I) !CONVERT EACH INTEGER READING TO REAL
190 !FORMAT (NECESSARY TO PREVENT POSSIBLE INTEGER OVERFLOW ON NEXT
    LINE)
190 R=ABS(Samp(I)) !USE ABSOLUTE VALUE TO CHECK FOR OVLD
200 IF R>=32767 THEN PRINT "OVLD" !IF OVLD, PRINT OVERLOAD MESSAGE
210 Samp(I)=Samp(I)*S !MULTIPLY READING TIMES SCALE FACTOR
220 Samp(I)=DROUND(Samp(I),4) !ROUND TO 4 DIGITS
230 NEXT I
235 !-----SORT SAMPLES-----
240 Inc=N1+N2 !TOTAL NUMBER OF BURSTS
250 K=1
260 FOR I=1 TO N1
270 L=I
280 FOR J=1 TO N3
290 Wave_form(L)=Samp(K)
300 K=K+1
310 L=L+Inc

```

```

320 NEXT J
330 NEXT I
340 FOR I=N1+1 TO N1+N2
350 L=I
360 FOR J=1 TO N3-1
370 Wave_form(L)=Samp(K)
380 K=K+ 1
390 L=L+Inc
400 NEXT J
410 NEXT I
420 END

```

SSPARM?

Sub-sampling parameters query. Returns the parameters necessary to reconstruct a sub-sampled waveform (SSAC or SSDC command) when the samples are sent directly to the GPIB output buffer. (Reconstruction is automatic when the samples are sent directly to reading memory.)

The first parameter returned by SSPARM? is the number of bursts that contained N samples. The second parameter is the number of bursts that contained $N-1$ samples. The third parameter returned is the value of N . For example, assume you are sub-sampling a 10 kHz signal and specify 22 samples with an *effective_interval* of 5 μ s. In this example, the multimeter must use a total of 4 bursts: 2 bursts contain 6 samples each and 2 bursts contain 5 samples each. The values returned by SSPARM? are then 2, 2, and 6.

Syntax

SSPARM?

Remarks

- **Related commands:** SSAC, SSDC, SSRC, SWEEP

Example

See the SSDC example on the preceding page.

SSRC

Sync source. For sub-sampling (SSAC or SSDC command), the SSRC command allows you to synchronize bursts to an external signal or to a voltage level on the input signal.

For synchronous ACV or ACDCV (SETACV SYNC command), the SSRC command allows you to synchronize sampling to an external signal. You can also use the HOLD parameter to prevent the measurement method from changing to random should level triggering not occur within certain time limits. The time limits are determined by the AC bandwidth (ACBAND command) setting.

Syntax

SSRC [*source*][*,mode*]

source

The *source* parameter choices are:

<i>source</i> parameter	Numeric query equiv.	Description
EXT	2	Synchronize to external input on the rear panel Ext Trig connector
LEVEL ^[a]	7	Synchronize to a voltage Level (LEVEL command) on the input signal using the slope specified by the SLOPE command.

[a] For synchronous ACV or ACDCV, the level triggering voltage (LEVEL command) and the slope (SLOPE command) are determined automatically and cannot be specified.

Power-on *source* = LEVEL

Default *source* = LEVEL

mode

The *mode* parameter applies only to synchronous ACV or ACDCV. The choices are:

<i>mode</i> parameter	Numeric query equiv.	Description
AUTO ^[a]	1	For synchronous AC or ACDCV (SETACV SYNC) using level triggering (default mode), if the input signal is removed during a reading and does not return within a certain amount of time, the measurement method changes to random so that the reading can be completed. (After the reading, the measurement method returns to SYNC.)
HOLD	4	The measurement method will not automatically change from synchronous to random when the input signal is removed.

[a] The time limit for synchronous AC or ACDCV is determined by the bandwidth specified using the ACBAND command.

Power-on *mode* = AUTO
Default *mode* = AUTO

Remarks

- For sub-sampling, the trigger event and the sample event are ignored. The only triggering events that apply to sub-sampling are the trigger arm event (TARM command) and the sync source event (SSRC command). For synchronous ACV or ACDCV measurements (SETACV SYNC command), the specified trigger arm event (TARM command), trigger event (TRIG command), and sample event (NRDGS command) must all be satisfied before the sync source event can initiate sampling.
- For sub-sampling and synchronous AC measurements, bursts of samples are taken on more than one period of the waveform. The sync source event synchronizes these bursts to the periods of the input signal (that is, a sync source event should typically occur once for each period).
- **Query command:** The SSRC? query command returns two responses separated by a comma. The first response is the present *source*. The second response is the present *mode*. Refer to **Query commands** near the front of this chapter for more information.

- **Related commands:** LEVEL, LFILTER, SETACV SYNC, SLOPE, SSAC, SSDC

Examples

In the program on the following page, the SSAC command is used to digitize a 10 kHz signal with a peak value of 5 V. The SWEEP command instructs the multimeter to take 1000 samples (Num_samples variable) with a 2 μ s *effective_interval* (Eff_int variable). The measurement uses the default level triggering for the sync source event (trigger from input signal, 0%, AC-coupling, positive slope). Line 120 generates a SYN event and transfers the samples directly to the computer. Lines 240 through 410 sort the sub-sampled data to produce the composite waveform. The composite waveform is stored in the Wave_form array.

```

10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 INTEGER Num_samples,Inc,I,J,K,L !DECLARE VARIABLES
30 Num_samples=1000 !DESIGNATE NUMBER OF SAMPLES
40 Eff_int=2.0E-6 !DESIGNATE EFFECTIVE INTERVAL
50 INTEGER Int_samp(1:1000) BUFFER !CREATE INTEGER BUFFER
60 ALLOCATE REAL Wave_form(1:Num_samples) !CREATE ARRAY FOR SORTED
70 DATA ALLOCATE REAL Samp(1:Num_samples) !CREATE ARRAY FOR SAMPLES
80 ASSIGN @Dvm TO 722 !ASSIGN MULTIMETER ADDRESS
90 ASSIGN @Int_samp TO BUFFER Int_samp(*) !ASSIGN BUFFER I/O PATH NAME
100 OUTPUT @Dvm;"PRESET FAST;LEVEL;SLOPE;SSRC LEVEL;SSDC 10"
101 !FAST OPERATION, TARM SYN, LEVEL SYNC SOURCE 0 V, POSITIVE SLOPE
105 !(DEFAULT VALUES) SUB-SAMPLING(SINT OUTPUT FORMAT), 10 V RANGE
110 OUTPUT @Dvm;"SWEEP ";Eff_int,Num_samples
115 !2  $\mu$ s EFFECTIVE INTERVAL, 1000 SAMPLES
120 TRANSFER @Dvm TO @Int_samp;WAIT !SYN EVENT,TRANSFER READINGS INTO
121 !INTEGER ARRAY; SINCE THE COMPUTER'S INTEGER FORMAT IS THE SAME AS
125 !SINT, NO DATA CONVERSION IS NECESSARY HERE (INTEGER ARRAY REQUIRED)
130 OUTPUT @Dvm;"ISCALE?" !QUERY SCALE FACTOR FOR SINT FORMAT
140 ENTER @Dvm; S !ENTER SCALE FACTOR
150 OUTPUT @Dvm;"SSPARM?" !QUERY SUB-SAMPLING PARAMETERS
160 ENTER @Dvm;N1,N2,N3 !ENTER SUB-SAMPLING PARAMETERS

```

```

170 FOR I=1 TO Num_samples
180 Samp(I)=Int_samp(I) !CONVERT EACH INTEGER READING TO REAL
190 !FORMAT (NECESSARY TO PREVENT POSSIBLE INTEGER OVERFLOW ON NEXT
    LINE)
190 R=ABS(Samp(I)) !USE ABSOLUTE VALUE TO CHECK FOR OVLD
200 IF R>=32767 THEN PRINT "OVLD" !IF OVLD, PRINT OVERLOAD MESSAGE
210 Samp(I)=Samp(I)*S !MULTIPLY READING TIMES SCALE FACTOR
220 Samp(I)=DROUND(Samp(I),4) !ROUND TO 4 DIGITS
230 NEXT I
235 !-----SORT SAMPLES-----
240 Inc=N1+N2 !TOTAL NUMBER OF BURSTS
250 K=1
260 FOR I=1 TO N1
270 L=1
280 FOR J=1 TO N3
290 Wave_form(L)=Samp(K)
300 K=K+1
310 L=L+Inc
320 NEXT J
330 NEXT I
340 FOR I=N1+1 TO N1+N2
350 L=I
360 FOR J=1 TO N3-1
370 Wave_form(L)=Samp(K)
380 K=K+ 1
390 L=L+Inc
400 NEXT J
410 NEXT I
420 END

```

In the following program, the SSRC EXT event is used with synchronous AC voltage measurements. After the trigger event occurs (the trigger arm and sample

events are AUTO), the first low-going TTL transition on the Ext Trig connector initiates the first burst. Each successive external trigger will then initiate a burst until the necessary number of bursts are completed.

```
10 OUTPUT 722;"PRESET NORM" !TARM AUTO, TRIG SYN, NRDGS 1,AUTO
20 OUTPUT 722;"ACV 10" !AC VOLTAGE, 10 V RANGE
30 OUTPUT 722;"SETACV SYNC" !SYNCHRONOUS METHOD
40 OUTPUT 722;"SSRC EXT" !EXTERNAL SYNC SOURCE EVENT
50 ENTER 722;A !TRIGGER READING (TRIG SYN), ENTER READING
60 PRINT A !PRINT READING
70 END
```

SSTATE

Store state. Stores the multimeter's present state and assigns it a name. States are recalled using the RSTATE command.

Syntax

SSTATE *name*

name

State name. A state name may contain up to 10 characters. The name can be alpha, alphanumeric, or an integer in the range of 0 to 127. When using an alphanumeric name, the first character must be alpha. Alpha or alphanumeric state names must not be the same as multimeter commands or parameters or the name of a stored subprogram. The characters _ and ? can also be used in an alpha or alphanumeric name.

When using an integer state name (0 - 127), the multimeter assigns the prefix *STATE* to the integer when the state is stored. This differentiates an integer state name from an integer subprogram name. For example, a state stored with the name 8 will be recorded as *STATE8*. The state can be recalled later using either the name 8 or *STATE8*. State 0 is reserved for the multimeter's power-down state (see first Remark below).

Power-on *name* = none.

Default *name* = none; parameter required.

Remarks

- Whenever the multimeter's power is removed, the present state is stored in state 0. After a power failure, the multimeter can be configured to its previous state by executing RSTATE 0.
- All states are stored in continuous memory (not lost when power is removed).
- Subprograms, the contents of reading memory, user-defined keys, and the front panel MENU mode are not included as part of a stored state. The contents of the following math registers are stored when you store a state (all other math registers are set to 0):

DEGREE	REF
LOWER	RES
OFFSET	SCALE
PERC	UPPER

- The multimeter has 14k-bytes of state memory. Each state occupies approximately 300 bytes allowing a maximum of 46 stored states. State 0 is reserved for storing the multimeter's state when power is removed. State 0 may be also be used for storing other states, but the stored state will be overwritten with the present state when power is removed.
- From the front panel, you can review the names of all stored states by pressing the **Recall State** key and using the up and down arrow keys. When you have found the desired state, press the **Enter** key to recall that state.
- **Related commands:** MSIZE, PURGE, RSTATE, SCRATCH

Example

OUTPUT 722;"SSTATE B2" !STORES PRESENT STATE WITH NAME B2

STB?

Status byte query. The status register contains seven bits that monitor various multimeter conditions. When a condition occurs, the corresponding bit is set in the status register. The STB? (status byte?) command returns a number representing the set bits. The returned number is the weighted sum of all set bits.

Syntax

STB?

Status register conditions

The status register conditions and their weights are:

Decimal weight	Bit number	Status register condition
1	0	Subprogram Execution Completed
2	1	Hi or Lo Limit Exceeded
4	2	SRQ Command Executed
8	3	Power On
16	4	Ready for Instructions
32	5	Error (Consult Error Register)
64	6	Service Requested (you cannot disable this bit)
128	7	Data Available

Remarks

- When you execute the STB? Command, the ready bit (bit 4) is always clear (not ready) because the multimeter is processing the STB? command.
- The CSB command clears the status register (bits 4, 5, and 6 are not cleared if the condition(s) that set the bit(s) still exist). The RQS command designates which status register conditions will assert SRQ on the GPIB bus.
- **Related commands:** CSB, EXTOUT, RQS, SPOLL (GPIB command)

Example

```

10 OUTPUT 722;"STB?" !RETURNS THE WEIGHTED SUM OF ALL SET BITS
20 ENTER 722 !ENTERS RESPONSE INTO COMPUTER'S A VARIABLE
30 PRINT A !PRINTS RESPONSE
40 END

```

Assume the above program returns the weighted sum 24. This means the bits with weighted values 8 (power-on) and 16 (ready for instructions) are set.

SUB

Subprogram. Stores a series of commands as a subprogram and assigns the sub-program name.

Syntax

SUB *name*

name

Subprogram name. A subprogram name may contain up to 10 characters. The name can be alpha, alphanumeric, or an integer from 0 to 127. When using an alphanumeric name, the first character must be alpha. Alpha or alphanumeric subprogram names must not be the same as multimeter commands or parameters or the name of a stored state. The characters _ and ? can also be included in an alpha or alphanumeric name.

When using an integer subprogram name (0 - 127), the multimeter assigns the prefix *SUB* to the integer when the subprogram is stored. This differentiates an integer subprogram name from an integer state name. For example, a sub-program stored with the name *15* will be recorded as *SUB15*. The subprogram can be accessed later using either the name *15* or *SUB15*. A subprogram named 0 (zero) is designated the autostart subprogram (see 7th Remark following).

Power-on *name* = none.

Default *name* = none; parameter required.

Remarks

- Subprogram entry is terminated by the SUBEND command. The CALL command is used to execute a subprogram, and the PAUSE and CONT commands suspend and resume subprogram execution, respectively.
- When you store a new subprogram using the name of an existing subprogram, the new subprogram overwrites (replaces) the old subprogram.
- Entering (storing) a subprogram from the front panel is not recommended since front panel utilities (e.g., up and down arrows) can inadvertently be stored in the subprogram. Once you have executed the SUB command from the front panel, the display shows SUB ENTRY MODE until the SUBEND command is executed or the RESET key is pressed. The SUBEND command does not appear in the front panel menu unless you are storing a subprogram.
- If a SCRATCH, DELSUB, a second SUB command, or the GPIB Device Clear command occurs in a subprogram, the multimeter does not store the command but does store the rest of the subprogram. Subprogram execution will be aborted if the RESET command is encountered (do not store RESET in a subprogram).
- You can not store a subprogram with less than 800 bytes of subprogram/state memory remaining.
- Subprogram execution will be aborted if an error is detected or the GPIB Device Clear command is received. The GPIB Device Clear command will also abort the process of storing a subprogram.
- The only way to take readings within a subprogram is to use the TARM SGL or TRIG SGL command. When either of these commands is encountered, the multimeter will not execute the next command in the subprogram until all specified readings are taken. (This also means all configuration and other triggering commands must occur before the TARM SGL or TRIG SGL command.) Any other trigger arm or trigger events (except TARM EXT, see next Remark) will be executed in a subprogram, but the readings will not be initiated until the subprogram is complete.
- Whenever the TARM EXT command is encountered in a subprogram, the multimeter waits until an external trigger is received on its Ext Trig connector before executing the next line of the subprogram. This allows you to synchronize subprogram execution to external equipment.

- Any subprogram named 0 will be automatically executed whenever the multimeter has finished its power-on sequence. This is useful to recall the multimeter's previous state (RSTATE 0) following a power failure.
- Subprograms are stored in continuous memory (not lost when power is removed). If you compress a subprogram, however, (COMPRESS command) the subprogram is removed from continuous memory and will be destroyed when power is removed.
- **Related commands:** CALL, COMPRESS, CONT, DELSUB, PAUSE, SCRATCH, SUBEND

Examples

```

10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 DIM RDGS(5) !DIMENSION ARRAY FOR 5 READINGS
30 OUTPUT 722;"SUB DCCUR2" !STORES FOLLOWING LINES NAMED DCCUR2
40 OUTPUT 722;"PRESET NORM" !PRESETS
50 OUTPUT 722;"MEM FIFO" !ENABLES FIFO MODE OF READING MEMORY
60 OUTPUT 722;"DCV, 10, .01" !DC VOLTAGE, 10 V RANGE, .01% RESOLUTION
70 OUTPUT 722;"NRDGS,5,AUTO" !5 READINGS PER TRIGGER, AUTO EVENT
80 OUTPUT 722;"TRIG SGL" !SPECIFIES THE SINGLE TRIGGER MODE
90 OUTPUT 722;"SUBEND" !SIGNALS THE END OF SUBPROGRAM STORAGE
100 OUTPUT 722;"DISP MSG 'CALLING SUBPROGRAM'"
110 OUTPUT 722;"CALL DCCUR2"
120 ENTER 722;Rdgs(*)
130 PRINT Rdgs(*)
140 END

```

When the following subprogram is called (CALL EXTPACE), the multimeter executes it line-by-line until it encounters TARM EXT (line 70). Subprogram execution then ceases until an external trigger occurs. This allows you to synchronize subprogram execution to some external event. After the first external trigger is received, subprogram execution resumes. When the next line is encountered (TRIG SGL), subprogram execution ceases until the 1000 readings are taken. After the readings are taken, the subprogram changes the measurement function to 2-wire ohms and the number of readings to 100. When the second TARM EXT command is encountered (line 100), subprogram execution

ceases until another external trigger occurs. After the external trigger is received, the TRIG SGL command is encountered which suspends subprogram execution until the 100 readings are taken. After the readings are taken, the message TEST FINISHED is displayed.

```

10 OUTPUT 722; "SUB EXTPACE" !STORE LINES 20-110 AS SUBPROGRAM
20 OUTPUT 722; "PRESET NORM" !PRESET, SUSPEND READINGS
30 OUTPUT 722; "MEM FIFO" !ENABLE READING MEMORY, FIFO MODE
40 OUTPUT 722; "DCV 10" !DC VOLTAGE MEASUREMENTS, 10 V RANGE
50 OUTPUT 722; "NRDGS 1000, AUTO" !1000 READINGS/TRIGGER,AUTO SAMPLE
EVENT
60 OUTPUT 722; "TARM EXT" !EXTERNAL TRIGGER ARM EVENT
70 OUTPUT 722; "TRIG SGL" !SINGLE TRIGGER EVENT
80 OUTPUT 722; "OHM 1E3" !2-WIRE OHMS, 1 kΩ RANGE
90 OUTPUT 722; "NRDGS 100, AUTO" !100 READINGS/TRIGGER, AUTO SAMPLE
EVENT
100 OUTPUT 722;"TARM EXT" !EXTERNAL TRIGGER ARM EVENT
110 OUTPUT 722;"TRIG SGL" !SINGLE TRIGGER EVENT
120 OUTPUT 722;"DISP MSG,'TEST FINISHED'" !INDICATE SUBPROGRAM IS DONE
130 OUTPUT 722;"SUBEND"
140 END

```

SUBEND

Subprogram end. Signals the end of a subprogram.

Syntax

SUBEND

Remarks

- When storing a subprogram, SUBEND signals the end of the subprogram. When a subprogram has been executed, SUBEND sets bit 1 (if enabled) in the status register which signals the subprogram's completion.
- **Related commands:** CALL, COMPRESS, CONT, DELSUB, PAUSE, SCRATCH, SUB

Example

See the SUB example on the preceding page.

SWEEP

The SWEEP command specifies the *effective_interval* between samples (readings and the total number of samples taken per trigger event [most measurement functions] or per trigger arm event (sub-sampling only).

Syntax

SWEEP [*effective_interval*] [,#_samples]

effective_interval

For sub-sampling (SSAC or SSDC), this parameter specifies the spacing of samples in the reconstructed waveform (see [Chapter 5](#) for details). For all other measurement functions, this parameter specifies the actual time interval from one sample to the next. For sub-sampling, the valid range of this parameter is 10E-9 to 6000 seconds with 10 ns increments; for all other measurement functions the range is (1/maximum reading rate) to 6000 seconds in 100 ns increments.

Power-on *effective_interval* = 100E-9

Default *effective_interval* = 20 μ s

#_samples

Specifies the number of samples to be taken. The valid range for this parameter is 1 to 1.67E+7.

Power-on *#_samples* = 1024

Default *#_samples* = 1024

Remarks

- The minimum effective interval for DC voltage measurements is 10 μ s; for direct-sampling, 20 μ s; for sub-sampling, 10 nanoseconds.
- The SWEEP command can be used to replace the NRDGS *n*,TIMER command and the TIMER command. The SWEEP and NRDGS are interchangeable; the multimeter uses whichever command was executed last in the programming. Executing the SWEEP command automatically sets the sample event to TIMER. In the power-on, RESET, or PRESET state, the multimeter uses the

NRDGS command. The power-on values for SWEEP can only be used for sub-sampling (since NRDGS does not apply to sub-sampling).

- You cannot use the SWEEP or TIMER functions for AC or AC+DC voltage measurements using the synchronous or random methods (SETACV SYNC or RNDM) or for frequency or period measurements.
- When using the SWEEP command (or TIMER event), autoranging is suspended (typically you should select a fixed range when using SWEEP).
- **Query command:** The SWEEP? query command returns two responses separated by a comma. The first response is the specified *effective_interval*. The second response is the specified *#_samples*. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** FUNC, NRDGS, TIMER

Example

In the program on the following page, the SSAC command is used to digitize a 10 kHz signal with a peak value of 5 V. The SWEEP command instructs the multimeter to take 1000 samples (Num_samples variable) with a 2 μ s *effective_interval* (Eff_int variable). The measurement uses the default level triggering for the sync source event (trigger from input signal, 0%, AC-coupling, positive slope).

Line 120 generates a SYN event and transfers the samples directly to the computer. Lines 240 through 410 sort the sub-sampled data to produce the composite waveform. The composite waveform is stored in the Wave_form array.

```

10 OPTION BASE 1 !COMPUTER ARRAY NUMBERING STARTS AT 1
20 INTEGER Num_samples,Inc,I,J,K,L !DECLARE VARIABLES
30 Num_samples=1000 !DESIGNATE NUMBER OF SAMPLES
40 Eff_int=2.0E-6 !DESIGNATE EFFECTIVE INTERVAL
50 INTEGER Int_samp(1:1000) BUFFER !CREATE INTEGER BUFFER
60 ALLOCATE REAL Wave_form(1:Num_samples) !CREATE ARRAY FOR SORTED DATA
70 ALLOCATE REAL Samp(1:Num_samples) !CREATE ARRAY FOR SAMPLES
80 ASSIGN @Dvm TO 722 !ASSIGN MULTIMETER ADDRESS
90 ASSIGN @Int_samp TO BUFFER Int_samp(*) !ASSIGN BUFFER I/O PATH NAME
100 OUTPUT @Dvm;"PRESET FAST;LEVEL;SLOPE;SSRC LEVEL;SSDC 10"
101 !FAST OPERATION, TARM SYN, LEVEL SYNC SOURCE 0 V, POSITIVE SLOPE

```

```

105 !(DEFAULT VALUES) SUB-SAMPLING(SINT OUTPUT FORMAT), 10 V RANGE
110 OUTPUT @Dvm;"SWEEP ";Eff_int,Num_samples
115 !2  $\mu$ s EFFECTIVE INTERVAL, 1000 SAMPLES
120 TRANSFER @Dvm TO @Int_samp;WAIT !SYN EVENT,TRANSFER READINGS INTO
121 !INTEGER ARRAY; SINCE THE COMPUTER'S INTEGER FORMAT IS THE SAME AS
125 !SINT, NO DATA CONVERSION IS NECESSARY HERE (INTEGER ARRAY REQUIRED)
130 OUTPUT @Dvm;"ISCALE?" !QUERY SCALE FACTOR FOR SINT FORMAT
140 ENTER @Dvm; S !ENTER SCALE FACTOR
150 OUTPUT @Dvm;"SSPARM?" !QUERY SUB-SAMPLING PARAMETERS
160 ENTER @Dvm;N1,N2,N3 !ENTER SUB-SAMPLING PARAMETERS
170 FOR I=1 TO Num_samples
180 Samp(I)=Int_samp(I) !CONVERT EACH INTEGER READING TO REAL
190 !FORMAT (NECESSARY TO PREVENT POSSIBLE INTEGER OVERFLOW ON NEXT
    LINE)
190 R=ABS(Samp(I)) !USE ABSOLUTE VALUE TO CHECK FOR OVLD
200 IF R>=32767 THEN PRINT "OVLD" !IF OVLD, PRINT OVERLOAD MESSAGE
210 Samp(I)=Samp(I)*S !MULTIPLY READING TIMES SCALE FACTOR
220 Samp(I)=DROUND(Samp(I),4) !ROUND TO 4 DIGITS
230 NEXT I
235 !-----SORT SAMPLES-----
240 Inc=N1+N2 !TOTAL NUMBER OF BURSTS
250 K=1
260 FOR I=1 TO N1
270 L=1
280 FOR J=1 TO N3
290 Wave_form(L)=Samp(K)
300 K=K+1
310 L=L+Inc
320 NEXT J
330 NEXT I

```



```

340 FOR I=N1+1 TO N1+N2
350 L=I
360 FOR J=1 TO N3-1
370 Wave_form(L)=Samp(K)
380 K=K+1
390 L=L+Inc
400 NEXT J
410 NEXT I
420 END

```

T

T is an abbreviation for the TRIG command.

Syntax

T [*event*]

Refer to the **TRIG** command for more information.

TARM

Trigger arm. Defines the event that enables (arms) the trigger event (TRIG command). You can also use this command to perform multiple measurement cycles.

Syntax

TARM [*event*][,*number_arms*]

event

The *event* parameter choices are:

event parameter	Numeric query equiv.	Description
AUTO	1	Always armed
EXT	2	Arms following a low-going TTL transition on the Ext Trig connector. (Executing TARM EXT clears the trigger buffer if TBUFF is ON).
SGL	3	Arms once (upon receipt of TARM SGL) then becomes HOLD
HOLD	4	Triggering is disabled
SYN	5	Arms when the multimeter's output buffer is empty, reading memory is off or empty, and the controller requests data.

Power-on *event* = AUTO.

Default *event* = AUTO.

number_arms

The *number_arms* parameter is valid only with the SGL trigger arm event; in this case, the valid range is 0 - 2.1E+9. Specifying 0 or 1 with the SGL event has the same effect as using the default value (1): the trigger is armed once and then reverts to the HOLD state (disabled). When you specify a number greater than 1 as the *number_arms* parameter, you have selected “multiple arming.” In multiple arming, the multimeter generates enough single trigger arms to satisfy the *number_arms* parameter. Refer to “multiple arming” in the Remarks section below for more information.

Power-on *number_arms* = 1 (multiple arming disabled)

Default *number_arms* = 1 (multiple arming disabled)

Remarks

- For all measurement functions except sub-sampling (see [Chapter 5](#)), the trigger arm event operates along with the trigger event (TRIG command) and the sample event (NRDGS or SWEEP command). To make a measurement, the trigger arm event must occur first, followed by the trigger event, and finally the sample event.
- The trigger arm event does not necessarily trigger the multimeter. It merely enables the trigger event, making it possible for the multimeter to respond to

the trigger event. Refer to [Triggering Measurements](#) in [Chapter 4](#) for an in-depth discussion of the interaction of the various events.

- Multiple arming: When using multiple arming, the trigger arm event must be specified as SGL. When the multimeter executes a TARM command specifying multiple arming, it holds the GPIB bus until all measurement cycles are complete. For example, if you specify *number_arms* as 5, and 10 readings per cycle (NRDGS command), there are 5 measurement cycles of 10 readings each. Since it holds the bus, the TARM command must be the last line in the program and you cannot use the synchronous trigger event or sample event.
- **Query command:** The TARM? query command returns the currently selected trigger arm event. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** NRDGS, SWEEP, TRIG

Examples

```
OUTPUT 722; "TARM AUTO, 0" !AUTO TRIGGER ARMING (ALWAYS ARMED)
```

```
10 OUTPUT 722; "TARM HOLD" !SUSPENDS MEASUREMENTS
20 OUTPUT 722; "OHM" !SELECTS 2-WIRE OHMS MEASUREMENTS
30 OUTPUT 722; "MEM FIFO !ENABLES READING MEMORY, FIFO MODE
40 OUTPUT 722; "NRDGS 5" !5 READINGS PER SAMPLE EVENT (AUTO)
50 OUTPUT 722; "TARM SGL" !ENABLES ONE SERIES OF MEASUREMENTS
60 END
```

```
10 OUTPUT 722; "DCV" !SELECTS DC VOLTAGE MEASUREMENTS
20 OUTPUT 722; "TARM HOLD" !SUSPENDS MEASUREMENTS
30 OUTPUT 722; "TRIG AUTO" !SELECTS AUTO AS THE TRIGGER EVENT
40 OUTPUT 722; "MEM FIFO" !ENABLES READING MEMORY, FIFO MODE
50 OUTPUT 722; "NRDGS 3, AUTO" !3 READINGS PER SAMPLE EVENT (AUTO)
60 OUTPUT 722; "TARM SGL,5" !SELECTS MULTIPLE ARMING FOR 5 CYCLES
70 END
```

In this program, line 60 arms the trigger once for each measurement cycle. This occurs five times. After the fifth cycle, trigger arming reverts to HOLD. This

program places 15 readings (3 readings per trigger event, 5 times) into reading memory.

Unless the input buffer is enabled, line 60 causes the GPIB bus to be held until all measurement cycles are complete. If you want to regain control of the bus immediately, suppress the `cr lf` by replacing line 60 with:

```
60 OUTPUT 722 USING "#,K"TARM SGL, 5;"
```

In the above line, the `#` image specifier suppresses the `cr lf`. The `K` image specifier suppresses trailing or leading spaces and outputs the command in free-field format. Notice the semicolon following the `TARM SGL,5`. This indicates the end of the command to the multimeter and must be present when you suppress `cr lf`.

TBUFF

Trigger buffer. Enables or disables the multimeter's external trigger buffer.

Syntax

TBUFF [*control*]

control

The *control* parameter choices are:

<i>control</i> parameter	Numeric query equiv.	Description
OFF	0	Disables the trigger buffer which enables the TRIGGER TOO FAST error
ON	1	Enables and clears the trigger buffer which disables the TRIGGER TOO FAST error

Power-on *control* = OFF.
Default *control* = OFF.

Remarks

- Setting TBUFF to ON corrects for a TRIGGER TOO FAST error that can occur when using an external EXT trigger arm, trigger, or sample event. With TBUFF OFF, any external trigger occurring during a reading generates the TRIGGER

TOO FAST error and the trigger(s) are ignored. With TBUFF ON, the first external trigger occurring during a reading is stored and no error is generated by this or any successive triggers. After the reading is complete, the stored trigger satisfies the EXT event if the multimeter is so programmed.

- Executing the RESET command sets TBUFF to OFF.
- **Query command:** The TBUFF? query command returns the present trigger buffering mode. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** EXTOUT, NRDGS, TRIG

Example

```
OUTPUT 722;"TBUFF ON" !DISABLES THE TRIGGER TOO FAST ERROR
```

TEMP?

Temperature query. Returns the multimeter's internal temperature in degrees Centigrade.

Syntax

TEMP?

Remarks

- Monitoring the multimeter's temperature is helpful to determine when to perform autocalibration.
- **Related commands:** ACAL, CAL, CALSTR

Example

```
10 OUTPUT 722; "TEMP?" !READ TEMPERATURE
20 ENTER 722; A !ENTER RESULT
30 PRINT A !PRINT RESULT
40 END
```

TERM

On previous multimeters, the TERM command internally connected or disconnected the multimeter's input terminals. The 3458A accepts the TERM command to maintain language compatibility with these multimeters, but does not respond since the 3458A's input terminals cannot be controlled from remote.

Syntax

TERM [*source*]

source

The *source* parameter choices are:

<i>source</i> parameter	Numeric query equiv.	Description
OPEN	0	Generates error message
FRONT	1	Generates error message if Terminals switch is set to Rear
REAR	2	Generates error message if Terminals switch is set to Front

Power-on *source* = none.
Default *source* = FRONT.

Remarks

- **Query command:** The TERM? query command returns a response indicating which input terminals (FRONT or REAR) are selected by the front panel Terminals switch.

TEST

Causes the multimeter to perform a series of internal self-tests.

Syntax

TEST

Remarks

- Always disconnect any input signals before you run self-test. If you leave an input signal connected to the multimeter, it may cause a self-test failure.
- If a hardware error is detected, the multimeter sets bit 0 in the error register and a more descriptive bit in the auxiliary error register. The display's ERR annunciator illuminates whenever an error register bit is set. You can access the error registers using ERRSTR? (both registers), ERR? (error register only), or AUXERR? (auxiliary error register only).
- **Related commands:** AUXERR?, ERR?, ERRSTR?

Example

```
OUTPUT 722; . "TEST" !RUNS SELF-TEST
```

TIMER

The TIMER command defines the time interval for the TIMER sample event in the NRDGS command. When using the TIMER event, the time interval is inserted between readings.

Syntax

TIMER [*time*]

time

The valid range of the *time* parameter is (1 /maximum sampling rate) to 6000 seconds in 100 ns increments.

Power-on *time* = 1 second.

Default *time* = 1 second.

Remarks

- When using the TIMER event, the first reading occurs without the time interval. However, you can insert a time interval before the first reading using the DELAY command.
- When using the TIMER event, autoranging is suspended (typically you should select a fixed range when using the TIMER event). If autoranging was enabled when you specified the TIMER sample event, autoranging will resume when you specify another sample event.
- The SWEEP command can be used to replace the two commands: NRDGS n ,TIMER and TIMER n for any measurement function. The SWEEP and NRDGS are interchangeable; the multimeter uses whichever command was executed last in the programming. Executing the SWEEP command automatically sets the sample event to TIMER. In the power-on, RESET, or PRESET state, the multimeter uses the NRDGS command. The power-on values for SWEEP can only be used for sub-sampling (since NRDGS does not apply to sub-sampling).
- You cannot use the TIMER (or SWEEP) event for AC or AC+DC voltage measurements using the synchronous or random methods (SETACV SYNC or RNDM) or for frequency or period measurements.
- **Query command:** The TIMER? query command returns the present time interval, in seconds, for the NRDGS timer event.
- **Related commands:** DELAY, NRDGS, SWEEP

Example

```

10 OUTPUT 722;"TRIG HOLD" !SUSPENDS MEASUREMENTS
20 OUTPUT 722;"INBUF ON" !ENABLES THE INPUT BUFFER
30 OUTPUT 722;"DCV 10" !DC VOLTAGE, 10 V RANGE
40 OUTPUT 722;"NPLC .1" !SELECTS .1 PLC OF INTEGRATION TIME
50 OUTPUT 722;"AZERO OFF" !DISABLES AUTOZERO
60 OUTPUT 722;"MEM FIFO" !ENABLES READING MEMORY (FIFO MODE)
70 OUTPUT 722;"TIMER 2" !SELECTS 2 SECOND INTERVAL
80 OUTPUT 722;"NRDGS 10 TIMER" !10 READINGS PER SAMPLE EVENT (TIMER)
90 OUTPUT 722;"TRIG SGL" !TRIGGERS ONCE
100 END

```


TONE

Causes the multimeter to beep once. The multimeter then returns to the previous BEEP mode (either OFF or ON).

Syntax

TONE

Related commands: BEEP

Example

`OUTPUT 722; "TONE" ! BEEPS`

TRIG

Specifies the trigger event.

Syntax

TRIG [*event*]

event

The *event* parameter choices are:

<i>event</i> parameter	Numeric query equiv.	Description
AUTO	1	Triggers whenever the multimeter is not busy
EXT	2	Triggers on low-going TTL signal on the Ext Trig connector
SGL	3	Triggers once (upon receipt of TRIG SGL) then reverts to TRIG HOLD)
HOLD	4	Disables readings
SYN	5	Triggers when the multimeter's output buffer is empty, memory is off or empty, and the controller requests data.
LEVEL ^[a]	7	Triggers when the input signal reaches the voltage specified by the LEVEL command on the slope specified by the SLOPE command.
LINE ^[b]	8	Triggers on a zero crossing of the AC line voltage

- [a] The LEVEL trigger event can be used only for DC voltage and direct-sampled measurements.
- [b] The LINE trigger event cannot be used for sampled AC or AC+DC voltage measurements (SETACV RDDM or SYNC) or for frequency or period measurements.

Power-on *event* = AUTO.

Default *event* = SGL.

Remarks

- For all measurements except sub-sampling (see [Chapter 5](#)), the trigger event operates along with the trigger arm event (TARM command) and the sample event (NRDGS command). (The trigger event and the sample event are ignored for sub-sampling.) To make a measurement, the trigger arm event must occur first, followed by the trigger event, and finally the sample event. The trigger event does not initiate a measurement. It merely enables a measurement, making it possible for a measurement to take place. The measurement is initiated when the sample event (NRDGS or SWEEP command) occurs. Refer to [Triggering Measurements](#) in [Chapter 4](#) for an in-depth discussion of the interaction of the various events for most measurement functions. Refer to [Chapter 5](#) for information on sub-sampling.
- **Query command:** The TRIG? query command returns the specified trigger event. Refer to [Query commands](#) near the front of this chapter for more information.
- **Related commands:** LEVEL, LFILTER, NRDGS, SLOPE, SWEEP, T, TARM, TBUF

Examples

OUTPUT 722; "TRIG AUTO" !SELECTS AUTO TRIGGER

The following program shows a method to suspend measurements until the multimeter is properly configured. Line 20 suspends measurements by setting the trigger event to HOLD. Lines 30 and 40 configure for 30 DC voltage readings per trigger event. Line 50 generates a single trigger causing the multimeter to make thirty readings. After the readings are complete, the trigger event reverts to HOLD.

10 OUTPUT 722;"RESET" !RETURN TO POWER-ON STATE

20 OUTPUT 722;"TRIG HOLD" !SUSPEND READINGS

```
30 OUTPUT 722;"DCV 10" !DC VOLTAGE MEASUREMENTS,10 V RANGE
40 OUTPUT 722;"NRDGS 30,AUTO" !30 READINGS PER SAMPLE EVENT (AUTO)
50 OUTPUT 722;"TRIG SGL" !GENERATES A SINGLE TRIGGER
60 END
```

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7 BASIC Language for the 3458A

Introduction	378
How It Works	379
BASIC Language Commands	380
New Multimeter Commands	383
3458A BASIC Language Example Program	384
Variables and Arrays	386
General Purpose Math	391
Subprograms	397
Writing and Loading Subprograms	398
Subprogram Command Types	400
Conditional Statements in Subprograms	405

Introduction

This chapter describes the BASIC commands supported by the 3458AA's internal BASIC language operating system. With this feature, many of your special requirements can be easily satisfied by writing and downloading a simple BASIC subprogram to customize the multimeter's behavior. The following is a list of possible situations where you might find the internal BASIC language to be useful.

- Customize the front-panel display readouts for enhanced user-friendliness.
- Add new measuring functions, math operations, or specialized transducer linearizations.
- Configure the multimeter to run extra high-throughput system measurements.
- Perform GPIB intensive data reduction internal to the multimeter.
- Download your Motorola 68000 binary programs for FFTs, etc.
- Keysight custom binary programs to satisfy your special needs.

How It Works

Simply create a new subprogram in the 3458AA's program memory space using the multimeter's SUB command. You may include any multimeter commands as discussed in chapter 6. You may also include any of the new BASIC language commands described in this supplement to build simple BASIC programs. *It's that easy – and yes, these commands will work with all revisions of the 3458AA's instrument firmware (except as noted).*

Subprograms can be called from the GPIB bus, assigned to a front-panel user-defined key (F0 through F9) for a single key press operation, or called from within another subprogram.

The 3458AA's BASIC language *does not* support the following concepts.

- String variables and operations
- Line numbers
- GOTO statements
- GOSUB statements
- Local variables (all variables are global)
- Parameter passing
- Any other BASIC commands not listed in this supplement.

BASIC Language Commands

This section gives you an overview of the BASIC language commands that are supported by the 3458AA's internal BASIC language operating system. Refer to the later sections in this chapter for more detailed information and examples on these commands.

Variables and arrays

NOTE

All array indexes are 0 to *size* (option base 0).

LET *user_variable* = *expression*

REAL *variable_1, variable_2, . . .* Declares a type real user variable. Also accepts **REAL** *variable_1 (size)* for declaring a real array. REAL is a 64-bit value.

INTEGER *variable_1, variable_2, . . .* Declares a type integer user variable. Also accepts **INTEGER** *variable_1 (size)* for declaring an integer array. INTEGER is a 16-bit value.

DIM *array_name (size), . . .* Dimensions an array.

FILL *array_name, list* Fills the named array with data from the following number list. Filled arrays are stored in *volatile* memory space.

NOTE

RESTRICTIONS ON USING VARIABLES IN SUBPROGRAMS

ALL subprograms that refer to a given variable must define it. The definition for a given variable must match all other definitions for the same variable name. If the definition for a user variable varies between subprograms, you may have problems when you cycle power. This is due to the way that the subprograms are stored internally to conserve memory. The subprogram executable code is actually rebuilt internally during the multimeter's power-on start-up routines.

Use the **FILL** command carefully. It does not work if power is cycled, the command is effectively deleted from the subprogram at this time. Use separate **LET** statements for each value assigned.

Math operations

Numeric Operations: +, -, *, /, ^
 =, >, <, >=, <=, <>
 DIV, MOD, ABS, SQR, LOG, EXP, LGT, SIN, COS, ATN
Binary Operations: AND, OR, EXOR, NOT, BINAND, BINCMP, BINEOR,
 BINIOR, BIT, ROTATE, SHIFT

Subprogram definition/deletion

SUB *sub_name* Identifies where the subprogram begins and assigns the name to the subprogram.

SUBEND *sub_name* Identifies where the subprogram ends and also terminates the entry of the subprogram.

DELSUB *sub_name* Deletes the specified subprogram from internal memory.

SCRATCH Deletes (scratches) all 3458AA subprograms, variables, and arrays from internal memory.

CAT Lists the names of all 3458AA subprograms, simple variables, stored states, and arrays that are presently stored in internal memory (limited to 400 characters).

LIST *sub_name* Lists the specified subprogram (limited to 400 characters).

COMPRESS *sub_name* Removes the text of the specified subprogram from memory.

Subprogram execution commands

CALL *sub_name* Executes the named subprogram and waits for completion before executing other commands.

PAUSE Pauses the most recent subprogram executed with the CALL command.

CONT Resumes subprogram execution after a PAUSE command is executed.

Looping and branching

```
FOR counter =initial_value TO final-value [STEP step_size]  
NEXT counter  
  
WHILE expression  
ENDWHILE  
  
IF expression THEN  
  [ ELSE ]  
ENDIF
```

Binary programs

CALLARRAY *array name, integer_list* Fetches the internal address of the specified array and begins execution there.

The array must have been previously loaded with data (*converted to ASCII*) using the FILL command. The binary data must be Motorola 68000 executable code written using relative addressing.

New Multimeter Commands

The following commands are not documented in chapter 6 but are included in this supplement for your convenience. These commands will work with all revisions of the 3458AA's instrument firmware (except as noted).

ENTER *user_variable* Transfers a reading from the multimeter's reading memory to a user variable. The multimeter reading is erased after execution. *Example:*
ENTER Dmm

OUTPUT *user_variable* Outputs the present value of a user variable. The data is sent to either to the display or GPIB output buffer based on the source from which the subprogram was executed. *Example:* OUTPUT Result

U_RANGE Up ranges once in the present function.

D_RANGE Down ranges once in the present function.

DISP *string* or *user_variable* Outputs to the multimeter's front-panel display both text and user variable data (*available only in REV 2.1 firmware and greater*).

DSP? Reads the present front-panel display.

SCROLL LEFT | RIGHT Scrolls the present front-panel display one character to the left or right. This applies only to text sent with the DISP command (for more information see chapter 6).

ECHO *string* Echoes the specified string back to either the multimeter's front-panel display or GPIB. The data is sent to either to the display or GPIB output buffer based on the source from which the subprogram was executed.

RETURN Used in a subprogram to return before the SUBEND statement.

RMATHV *register, user_variable* Reads a standard multimeter math register into a user variable (*available only in REV 5.1 firmware and greater*).

WAIT *msec* Wait before executing the next command (32 seconds maximum).

3458A BASIC Language Example Program

The following example program illustrates the use of the 3458AA's internal BASIC language along with the use of new multimeter commands. This program example uses a Series 300 BASIC computer for program development and for downloading the program to the multimeter over the GPIB interface. The multimeter's bus address is 22 and the computer's GPIB interface address is set to 700.

```

10 !
20 ! The following program uses the 3458AA to calculate
30 ! the mean (throwing away the largest and smallest values).
40 ! Four BASIC language commands are used:
50 ! RMATHV, LET, REAL, and OUTPUT.
60 !
70 !
80 ! RMATHV - Fills a variable with the present value of
90 !           a math register; similar to RMATH.
100 !
110 ! OUTPUT - Returns the value to the source from which the command
120 !           was executed (since the example called the
130 !           subprogram from the GPIB bus, the value of
140 !           AVG is sent over the bus).
150 !
160 ! LET and REAL - Assign values to the specified variables.
170 !
180 !
190 !
200 DIM Rdgs(1:300)           ! Dimension data array in computer
210 ASSIGN @Dvm TO 722        ! Set up GPIB address
220 !
230 CLEAR @Dvm
240 OUTPUT @ Dvm; "RESET"
250 WAIT 0.5
260 !
270 OUTPUT @Dvm; "PRESET FAST"
280 OUTPUT @Dvm; "OHM 1000"
290 OUTPUT @Dvm; "APER 167E-6"
300 OUTPUT @ Dvm; "OFORMAT ASCII"
310 OUTPUT @Dvm; "MEM FIFO"
320 OUTPUT @Dvm; "NRDGS 300,TIMER" ! Set up to acquire 300 readings
330 OUTPUT @Dvm; "TIMER 0.0002"    ! 5000 Rdgs/sec sample rate
340 !
350 !

```

```

360 !
370 OUTPUT @Dvm; "SUB CALC_MEAN"      ! Start of DMM subprogram
380 OUTPUT @Dvm; "REAL BIG,SMALL,AVG" ! Dimension user variables
390 OUTPUT @Dvm; "MMATH STAT"
400 OUTPUT @Dvm; "RMATHV MEAN, AVG"    ! New DMM command
410 OUTPUT @Dvm; "RMATHV UPPER, BIG"   ! New DMM command
420 OUTPUT @Dvm; "RMATHV LOWER, SMALL" ! New DMM command
430 OUTPUT @Dvm; "LET M=(AVG*300-BIG-SMALL)/298" !Expression to calc M
440 OUTPUT @Dvm; "OUTPUT M"            ! Send calc'ed result to bus
450 OUTPUT @Dvm; "SUBEND"              ! End of DMM subprogram
460 OUTPUT @Dvm; "TARM SGL"            ! Trigger dmm acquisition
470 T0=TIMEDATE                        ! Store start time
480 T1=TIMEDATE
490 OUTPUT @ Dvm; "CALL CALC_MEAN"     ! Tell DMM to execute sub
500 ENTER @Dvm; Mean                   ! Read M into computer
510 T2=TIMEDATE                        ! Store end time
520 PRINT"MEAN";Mean;"TRANSFER AND CALCULATION SPEED";T2-T1-(T1 -T0)
530 PRINT
540 END

```

Sample results from program execution:

```
MEAN 54.73391112 TRANSFER AND CALCULATION SPEED .399963378906
```

Variables and Arrays

The 3458AA employs two forms of numeric variables: simple variables (also called “scalars”) and subscripted arrays. Variable usage in the 3458AA is very similar to variable usage in an enhanced BASIC language. The 3458AA *does not* provide string variables. All variables are global among front panel, GPIB, and subprogram operations. This means that you can dynamically change variable values.

Type declarations

The 3458AA uses two data types for its variables: Integer or Real. All variables are real unless you declare them as integer. The valid range for real numbers is:

$$-1.797\ 693\ 134\ 862\ 315 \times 10^{308} \text{ to } 1.797\ 693\ 134\ 862\ 315 \times 10^{308}$$

The smallest non-zero real value allowed is:

$$\pm 2.225\ 073\ 858\ 507\ 202 \times 10^{-308}$$

A real number can have a value of zero.

An integer can have any whole-number value from:

$$-32767 \text{ through } +32767$$

The DIM command declares real arrays. The INTEGER command declares integer variables or arrays. The REAL command declares real variables or arrays.

The following program statement declares real array A with 10 elements (numbered 0 through 9).

```
OUTPUT 722; "DIM A(9)"
```

The following program statement declares integer array IARRAY with 10 elements (numbered 0 through 9) and integer variable B.

```
OUTPUT 722; "INTEGER IARRAY(9),B"
```

The following program statement declares real array RARRAY with 10 elements (numbered 0 through 9) with real variable C.

```
OUTPUT 722; "REAL RARRAY(9), C"
```

The 3458AA declares variables automatically when a variable name appears in an assignment statement with the LET command. For example, the following statements automatically declare the variable names specified.

```
OUTPUT 722; "LET A=SIN(.223)"
```

OUTPUT 722; "LET B=3.14159"

Some 3458AA commands expect a specific variable type when defining variables for parameters. For example, the TIME command expects a real number. Similarly, commands which return numeric results will return specific number types. The LINE? command returns an integer number. Measurements returned are real numbers. All variables are REAL unless otherwise specified.

NOTE

PROGRAMMING HINT

Once you declare an array type, you cannot re-declare it as a different type without scratching memory first (see the SCRATCH command in chapter 6). If you refer to a real number within a command that expects an integer, the 3458AA converts the real number to an integer. Likewise, if you refer to an integer number within a command that expects a real number, the 3458AA converts the integer number to a real number. Therefore, you can minimize system overhead time by allocating variables according to their use. For example,

OUTPUT 722; "REAL TIME_INT; LET TIME_INT=2.25; TIMER TIME_INT"

Type conversions

The 3458AA automatically converts between real and integer values whenever necessary. When real numbers are converted to integer representations, information may be lost. Two potential problem areas exist in this conversion, rounding errors and range errors.

- When a real number is converted to an integer, the real value is rounded to the closest integer value. All information to the right of the decimal point is lost.
- Range errors exist when converting real values to integer values. While real values range from approximately -10^{308} to $+10^{308}$, the integer range is only from -32768 to $+32767$ (approximately -10^4 to $+10^4$). Therefore, not all real numbers can be rounded to an equivalent integer value. This problem can generate "Integer Overflow" error.

Using variables

Simple variable and array names may contain up to 10 characters. The first character must be a letter (A–Z) but the remaining nine characters can be letters, numbers (0–9), the underscore character (“_”), or the question mark (“?”). Upper case is the same as lower case. *Variable names must not be the same as 3458AA commands, parameters, or stored state names.*

You can assign any numeric variable with the LET command (the keyword "LET" is required). For example, the following statements are equivalent.

```
OUTPUT 722; "LET TIME_INT = 120E-3"
```

```
OUTPUT 722; "LET TIME_INT =40*3E-3"
```

Variables can replace numeric parameters in any 3458AA command that uses numeric parameters. Two examples uses are (1) numeric data storage and (2) numeric calculations. The following sections discuss these two uses.

Variables for data storage

At power-on, numeric output data generated by the 3458AA is placed into the GPIB output buffer where it can be sent to the system controller. However, for some applications you may want to store the output data directly into the multimeter's internal memory. The ENTER command takes one reading out of reading memory (destructively) and places the value in the specified variable or array location.

The following program uses the ENTER command within a 3458AA subroutine to store readings.

```
10 OUTPUT 722; "SUB DMM_CONF"
20 OUTPUT 722; "NRDGS 100"
30 OUTPUT 722; "TRIG SGL"
40 OUTPUT 722; "INTEGER I"
50 OUTPUT 722; "FOR I = 1 TO 100"
60 OUTPUT 722; " ENTER A[I]"
70 OUTPUT 722; "NEXT I"
80 OUTPUT 722; "SUBEND"
90 !
100 OUTPUT 722; "CALL DMM_CONF"
110 END
```


Numeric calculations

Any variables, whether simple or array, can be used in numeric calculations. Several math functions are available in the 3458AA command set to allow you to manipulate data. The 3458AA's math functions are described in more detail later in this supplement.

Reading multimeter values

The OUTPUT command returns the value of a specified variable. An example is included below to illustrate the use of the OUTPUT command.

```
10 DIM A$[50]!Dimension controller variable
20 OUTPUT 722; "LET VAL=COS(.5235)!Compute value
30 OUTPUT 722; "OUTPUT VAL"!Read result into variable
40 ENTER 722: A$!Enter result
50 PRINT A$!Print result
60 END
```

Arrays

You can allocate memory space in the 3458AA for one-dimensional arrays. For real arrays, use either the DIM *name(size)* or REAL *name(size)* commands to define the array. For integer arrays, use the INTEGER *name(size)* command. All arrays have a lower bound of zero (option base 0). Arrays do not have a default size. For example, to create a 10-element array, specify a size of 9 as shown below.

```
OUTPUT 722; "DIM TESTER(9)"
```

Array names are subject to the same rules as numeric variable names. To specify a particular array element, you must specify the subscript enclosed in parentheses. The range of subscripts is an integer from 0 through 999, but the maximum array size is determined by available 3458AA memory (approximately 10 kbytes if no stored states or subprograms are stored). A non-integer subscript is rounded to the nearest integer.

Arrays may be resized by re-declaring them. This initializes each element in the array to a value of zero. You cannot, however, redefine the type of array (real or integer) without scratching memory first (refer to the SCRATCH command in chapter 6). Array elements may be used in the same ways simple variables are used.

Filling arrays

Array elements are initialized to zero when they are declared (DIM, REAL, or INTEGER commands) or are re-sized. Once you have dimensioned an array, use the FILL command to load your values into the array. The FILL command has the following syntax:

FILL *array_name, List*

The following program fills an integer array with integer values.

```
10 OUTPUT 722; "INTEGER LIST(9)"
20 OUTPUT722; "FILL LIST 0,100,200,300,400,500,600,700,800,900"
30 END
```

NOTE

Use the FILL command *carefully*. It does not work if power is cycled. The command is effectively deleted from the subprogram at this time. Use separate LET statements for each value assigned.

Array size

The SIZE? query command returns the number of elements in the specified array. This number is one more than the index of the last element in the array due to the option base 0 convention used by the 3458AA. Thus, if you dimension a 10-element array (e.g., DIM LIST(9)), the SIZE? command will return "10".

The following program defines an integer array with 10 elements and then verifies the array size using the SIZE? command.

```
10 OUTPUT 722; "INTEGER IARRAY(9)"
20 OUTPUT 722; "SIZE? IARRAY"
30 ENTER 722; A
40 PRINT A
50 END
```

Purging arrays and variables

All variables and arrays are stored in 3458AA volatile memory. If the 3458AA loses power, all variables and arrays are lost. The SCRATCH command also purges all variables, arrays, subprograms, and stored state names (stored states are explained in chapter 3).

General Purpose Math

You can use general purpose math expressions, following standard BASIC language conventions, from either the front-panel keyboard, the system controller, or within 3458AA subprograms. The standard math operators, general math functions, trigonometric functions, and binary functions are available. The 3458AA also has a simple calculator mode.

Math operators

In addition to the standard math operators (+ - * / ^), two additional arithmetic operators exist in the 3458AA. These operators are DIV (integer division) and MOD (modulo). Unary minus operations should be written as:

```
A = 0-B
```

The DIV command returns the integer portion of a division. Normal division takes place but all digits to the right of the decimal point are truncated (not rounded). The following program divides 7 by 3 and displays the integer portion of the division (2) on the system controller.

```
10 OUTPUT 722; "OUTPUT(7 DIV 3)"
20 ENTER 722; A
30 PRINT "DIV Result ="; A
40 END
```

Typical Printout:

```
DIV Result = 2
```

The MOD command returns the remainder portion of a division. As with the DIV command, normal division takes place; however, MOD returns only the remainder. The following program divides 7 by 3 and displays the remainder portion of the division (1) on the system controller.

```
10 OUTPUT 722; "OUTPUT(7 MOD 3)"
20 ENTER 722; A
30 PRINT "MOD Result="; A
40 END
```

Typical Printout:

```
MOD Result=1
```

Relational math operators (< > <= >= <>) and logical operators (AND and OR) are allowed in any expression.

General math functions

The following table lists the general math functions available in the 3458AA. The arguments (denoted by “X” and “Y”) may be numbers, numeric variables, functions, array elements, or numeric expressions in parentheses.

Function/Argument	Meaning
ABS(X)	Absolute value of argument.
SQR(X)	Positive square root of argument.

Logarithmic functions

The 3458AA can compute both natural and common logarithms. The logarithmic functions are shown in the following table.

Function/Argument	Meaning
LOG(X)	$\text{Log}_e(X)$: Natural logarithm of a positive argument to the base e (2.71828).
EXP(X)	e^X : Natural antilogarithm. Raises e to the power of the argument.
LGT(X)	Log_{10} : Common logarithm of a positive argument to the base 10.

Trigonometric Functions

Three trigonometric functions are provided in the 3458AA. The trigonometric functions are shown in the following table.

Function/Argument	Meaning (X in radians)
SIN(X)	Sine of argument.
COS(X)	Cosine of argument.
ATN(X)	Arctangent of argument.

Logical functions

The 3458AA has four logical functions: AND (inclusive-AND), OR (inclusive-OR), EXOR (exclusive-OR), and NOT (logical inverse). The first three functions compare the two arguments and return either a "0" or a "1" based on the respective truth table. Any non-zero value (positive or negative) in an argument is considered a logical "1". Only zero is treated as a logical "0".

The logic function commands have the following syntax. The truth tables for the four functions are shown below.

argument **AND** *argument*

argument **OR** *argument*

argument **EXOR** *argument*

NOT *argument*

A	B	A AND B	A OR B	A EXOR B	NOT A	NOT B
0	0	0	0	0	1	1
0	1	0	1	1	1	0
1	0	0	1	1	0	1
1	1	1	1	0	0	0

Binary functions

The 3458AA provides seven binary functions. These can help in digital pattern generation. When using the binary functions, argument values ("X" and "Y") of real variables are rounded to integers in the range -32768 to +32767. The binary functions are shown in the table below.

Function/Argument	Meaning
BINAND(X,Y)	Bit-by-bit logical AND of the arguments.
BINCMPI(X)	Bit-by-bit binary complement of the argument.
BINEOR(X,Y)	Bit-by-bit logical Exclusive-OR of the arguments.
BINIOR(X,Y)	Bit-by-bit logical Inclusive-OR of the arguments.

Function/Argument	Meaning
BIT(X,position)	Returns "0" or "1" representing the logic value of the specified bit of the argument. The bit position is in the range 0 (lsb) to 15 (msb).
ROTATE(X,displacement)	Returns an integer obtained by rotating the argument a specified number of positions <i>with bit wraparound</i> ^[a]
SHIFT(X,displacement)	Returns an integer obtained by rotating the argument a specified number of positions <i>without bit wraparound</i> .*

[a] If the displacement is positive, rotating or shifting is toward the least significant bit. If the displacement is negative, rotating or shifting is toward the most significant bit.

Math hierarchy

The 3458AA evaluates parenthetical expressions before evaluating any math functions outside of parentheses. If two or more operations of the same priority are in the expression, the hierarchy is from left to right

Highest Priority	Parentheses Functions: SIN, COS, etc. Exponentiation *, /, MOD, DIV +, -
Lowest Priority	Relational Operators: <, >, <=, >=, etc. logical operators: AND, OR, etc.

Math errors

When evaluating a math expression, the following errors may occur. The 3458AA treats math errors just like any other execution errors. Refer to chapter 3 for more information on handling errors.

Error description
Division by Zero
Real Overflow
Real Underflow
Integer Overflow
Square Root of a Negative Number
Log of a Non-Positive Number
Illegal Real Number
Trig Argument Out of Range
BCD Exponent Too Big
HEX, Octal, or Decimal Argument Error

Making comparisons work

If you are making mathematical comparisons between integer numbers, no special precautions are necessary. However, if you are comparing REAL numbers, especially those which are the results of calculations, it is possible that you might run into problems due to rounding and other limitations inherent in the system. For example, consider the use of the IF...THEN statement to check for equality in any situation resembling the following example.

```

10 OUTPUT 722; "SUB TESTER"
20 OUTPUT 722; "LET A=25.3765477"
30 OUTPUT 722; "IF SIN(A)^2 + COS(A)^2 = 1 THEN"
40 OUTPUT 722; " DISP 'EQUAL'"
50 OUTPUT 722; "ELSE"
60 OUTPUT 722; " DISP'NOT EQUAL'"
70 OUTPUT 722; " ENDIF"
80 OUTPUT 722; "SUBEND"
```

```
90 !  
100 OUTPUT 722; "CALL TESTER"  
110 END
```

You may find that the equality test fails due to rounding errors or other errors caused by the inherent limitations of finite machines. A repeating decimal or irrational number cannot be represented exactly in any finite machine like the 3458AA.

A good example of equality error occurs when multiplying or dividing numbers. A product of two non-integer values nearly always results in more digits to the right of the decimal point than existed in either of the two numbers being multiplied.

Subprograms

The 3458AA can store and execute BASIC language subprograms. These subprograms can either be downloaded into 3458AA memory from a remote system controller (such as one of the HP Series 200/300 computers) or you can enter the subprogram from the front-panel keyboard. This section acquaints you with the structure and usage of subprograms. It also discusses specific commands, which are used within subprograms.

A subprogram is a series of 3458AA commands beginning with the SUB command and ending with the SUBEND command. The SUB command assigns a name to the subprogram which you use to execute the subprogram at a later time. Subprograms are stored in 3458AA non-volatile memory.

Subprograms downloaded into the 3458AA can be executed later with a single command from the system controller or front-panel keyboard. This allows the system controller to perform other tasks while the 3458AA is busy with other activities. This provides multi-tasking capability to your system controller because the 3458AA is acting like a separate computer running tasks by itself. Also, commands within an 3458AA subprogram execute faster than those same commands received over the GPIB because of the way the 3458AA stores the subprogram commands internally.

What Commands Are Allowed Within a Subprogram?

Most commands for the 3458AA may be stored and executed inside a subprogram. The only commands which cannot be stored are CONTINUE, COMPRESS, DELSUB, and SCRATCH. Three conditional and looping commands are provided for use within subprograms.

How Many Different Subprograms Can Be Stored?

The exact number of subprograms which can be stored in 3458AA memory depends on the individual sizes of the subprograms. A typical subprogram containing 10 commands (including the SUB and SUBEND commands) might average about 600 bytes. Refer to chapter 3 for more information on memory usage.

Can I Nest Subprograms?

Yes! Nesting subprograms is the ability to have one subprogram call (execute) another subprogram. You can nest up to 10 subprograms.

Writing and Loading Subprograms

The subprogram example programs in this section illustrate relatively simple 3458AA operations which you can copy and use in more complex mainline programs of your own design. This section also shows how to create and edit subprograms.

NOTE

PROGRAMMING HINT

You should execute the **SCRATCH** command and download the subprograms from your system controller at the beginning of your test system program. This helps memory management for the 3458AA and ensures that the subprograms are downloaded and ready when they are needed.

Executing the **SUB** command instructs the 3458AA to store all subsequent commands, until the **SUBEND** command, in the specified subprogram.

Subprogram names may contain up to 10 characters. The first character must be a letter (A–Z) but the remaining nine characters can be letters, numbers (0–9), the underscore character (“_”), or the question mark (“?”). Subprogram names must not be the same as 3458AA commands or parameters, previously defined array or variable names, or stored state names.

The following program shows how to create a simple subprogram which configures the multimeter to make three dc voltage measurements.

```
10 OUTPUT 722; "SUB DMM_CONF"
20 OUTPUT 722; "DCV8,0.00125"
30 OUTPUT 722; "NRDGS 3"
40 OUTPUT 722; "TRIG SGL"
50 OUTPUT 722; "SUBEND"
60 END
```

The two statements **SUB DMM_CONF** and **SUBEND** along with the three commands on line 20, 30, and 40 form the subprogram named **DMM_CONF**.

When a subprogram is entered, the 3458AA checks for syntax errors just like any other commands. If the syntax is not correct, an error is generated and the command is not stored in the subprogram. You must then edit your subprogram in the system controller and download it again. The 3458AA stores the subprogram in non-volatile memory. You can then execute the subprogram from either the front-panel keyboard or the system controller. The subprogram will not be stored

if a subprogram nesting error exists when the SUBEND command is executed (e.g., if one of the called subprograms does not exist in 3458AA memory).

If you create or download a subprogram using a subprogram name which already exists in 3458AA memory, the new subprogram overwrites the previous subprogram.

Subprogram Command Types

The 3458AA's subprogram-related commands are used only within subprograms. Subprogram definition and deletion commands deal with the storage, viewing, and deletion of subprograms from internal memory. Execution commands control execution of subprograms from inside or outside a subprogram.

Definition/Deletion commands

Subprogram definition and deletion commands identify the beginning and end of subprograms, store and delete subprograms from memory, and list the subprograms presently stored in internal memory.

The syntax statements for the subprogram definition and deletion commands are shown below.

SUB *sub_name*

SUBEND

DELSUB *sub_name*

SCRATCH

CAT

LIST *sub_name*

COMPRESS *sub_name*

SUB/SUBEND

Every 3458AA subprogram must contain a SUB and SUBEND command. The SUB command must be the first line in all 3458AA subprograms. It identifies where the subprogram begins and assigns the name to the subprogram. When the SUB command is executed, the 3458AA begins storing the subprogram in internal memory.

The SUBEND command must be the last line in all 3458AA subprograms. It identifies where the subprogram ends and also terminates the entry of the subprogram. Commands listed between the SUB and SUBEND commands are executed, in order, every time the subprogram is executed.

Only one SUB and one SUBEND command is allowed in any one subprogram. Additional SUB or SUBEND commands will generate errors.

DELSUB

The DELSUB (delete subprogram) command deletes the specified subprogram from internal memory but does not delete the subprogram name itself from the catalog listing of subprograms (CAT command).

SCRATCH

The SCRATCH command deletes (scratches) all 3458AA subprograms, variables, and arrays from internal memory. It also deletes all name definitions from the catalog listing (CAT command). If SCRATCH is executed when a subprogram is running, an error is generated but the subprogram is not purged from memory.

CAT

The CAT (catalog) command lists the names of all 3458AA subprograms, simple variables, stored states, and arrays that are presently stored in internal memory. If there are no more arrays or subprograms to be listed, the CAT command returns the word "DONE". Refer to chapter 3 for more information on stored states. The format for the catalog is:

For Subprograms: **SUB** *sub_name*

For Integer Arrays: **IARRAY** *array_name*

For Real Arrays: **RARRAY** *array_name*

For Stored States: **STATE** *state_name* (non-volatile memory)

For Simple Variables: **INT** *variable_name*
REAL *variable_name*

The following program shows how to use the CAT command.

```
10 DIM A$[80]
20 OUTPUT 722; "CAT"
30 REPEAT
40   ENTER 722; A$
50   PRINT A$
60 UNTIL A$="DONE"
70 END
```

LIST

The LIST command allows you to list the specified subprogram. Keep in mind that you cannot edit subprograms from the front panel; you must edit them from your

system controller. The following program shows how to list the subprogram DMM_CONF to your system controller.

```
10 DIM A$[100]
20 OUTPUT 722; "LIST DMM_CONF"
30 REPEAT
40   ENTER 722; A$
50   PRINT A$
60 UNTIL A$="SUBEND"
70 END
```

COMPRESS

The COMPRESS command removes the text of the specified subprogram from internal memory (the subprogram is no longer stored in non-volatile memory and is lost when power is removed). This saves space in internal memory but eliminates the ability to list (LIST command) the subprogram. The COMPRESS command should be used only after the subprogram has been debugged and tested.

Execution Commands

Subprogram execution commands control the execution of a subprogram. The syntax statements for the subprogram execution commands are shown below.

CALL *sub_name*

PAUSE

CONT

Subprogram CALL

The CALL command executes the named subprogram and waits for completion before executing other commands. This means that no subsequent commands are accepted (either from the GPIB interface or the front-panel keyboard) until the subprogram finishes. The Ready Bit (bit 4 in the 3458AA Status Register) remains "0" while the subprogram is executing. When the subprogram finishes execution, the Ready Bit is set to "1" indicating that the 3458AA is ready to receive additional commands.

The CALL command may also be used in a subprogram to call another subprogram. This provides the expanded capability of "nested" subprograms. When using nested subprograms, the calling subprogram is suspended so that

only one subprogram is running at a time. Subprograms can be nested up to 10 deep.

Subprogram PAUSE

The PAUSE command pauses the most recent subprogram executed with the CALL command. Once a subprogram has been paused, you must execute the CONT (continue) command to resume execution. The CONT command allows the subprogram to continue running to completion, starting with the next command after the PAUSE command.

The 3458AA will generate an error if you attempt to execute the CONT command when a subprogram is not paused.

Knowing When a Subprogram is Paused

The PAUSED? query command returns a "1" if the subprogram is currently paused or a "0" if the subprogram is running (or finished running). The following program shows how to use the PAUSED? command.

```
10 OUTPUT 722; "RUN DMM_CONF;PAUSE"
20 OUTPUT 722; "PAUSED?"
30 ENTER 722; A
40 IF A=1 THEN PRINT "SUBPROGRAM IS PAUSED"
50 IF A=0 THEN PRINT "SUBPROGRAM IS NOT PAUSED"
60 END
```

Aborting a Subprogram

The GPIB CLEAR command (see [Appendix B](#)) aborts execution of a subprogram executed with the CALL command. This returns control to the GPIB command input buffer or the front-panel keyboard.

Exiting a Subprogram

A subprogram will continue to execute until it reaches the SUBEND command. Control then reverts back to either the subprogram that called it (nested subprograms) or to the GPIB input buffer or front-panel keyboard (whichever executed the subprogram). The RETURN command can also be used to end the subprogram. For example, if you want to have a conditional termination of the subprogram, place RETURN within an IF...THEN loop in the subprogram. The RETURN command returns control to the caller without executing the SUBEND command. For example,

```

10 OUTPUT 722; "SUB DMM_CONF"
20 OUTPUT 722; "DCV 8, 0.00125"
30 OUTPUT 722; "TRIG SGL"
40 OUTPUT 722; "ENTER A"
60 OUTPUT 722; "IF A<5.06 THEN; RETURN"
70 OUTPUT 722; "ELSE"
80 OUTPUT 722; "TRIG SGL"
90 OUTPUT 722; "ENDIF"
100 OUTPUT 722; "SUBEND"
110 !
120 OUTPUT 722; "CALL DMM_CONF"
130 END

```

Nesting Subprograms

One subprogram may call a second (nested) subprogram for execution before the first subprogram finishes execution. When the second subprogram executes the SUBEND command, the first subprogram continues with the next command following the embedded CALL command.

The 3458AA has two requirements for nesting subprograms. First, the subprogram called from within another subprogram must be stored in internal memory before the subprogram doing the calling is stored. This is because the 3458AA checks the syntax of each command as it stores the subprogram. When it encounters an embedded CALL command, the 3458AA checks to see if a subprogram by that name exists in memory. If not, it generates an error. Second, subprograms may not be nested more than 10 levels deep. You cannot place one subprogram inside of another subprogram. For example, the following program will generate an error.

```

10 OUTPUT 722; "SUB DMM_CONF"
20 OUTPUT 722; "DCV8,0.00125"
30 OUTPUT 722; "SUB TESTER" !This results in an error
40 OUTPUT 722; "SUBEND"
50 !
60 OUTPUT 722; "CALL DMM_CONF"
70 END

```


Conditional Statements in Subprograms

The 3458AA provides three BASIC language statements for conditional branching and looping. Use these statements only within 3458AA subprograms. Conditional branching and looping statements provide for repetitive tests, initializing arrays, etc.

The three conditional statements are: FOR...NEXT, WHILE...ENDWHILE, and IF...THEN. These statements are similar to those used in an enhanced BASIC language. The only exception is that 3458AA subprograms do not have line numbers or GOTO statements for branching. Looping and conditional branching statements may be nested seven deep.

FOR...NEXT Loops

The FOR...NEXT command defines a loop which is repeated until a loop counter passes a specified value. The syntax statement for the FOR...NEXT command is shown below.

```
FOR counter = initial_value TO final_value [STEP step_size]
program segment
NEXT counter
```

The *counter* parameter is a variable name which acts as the loop counter. The *initial_value* parameter and *final_value* parameter may be numbers, numeric variables, or numeric expressions. The optional *step_size* parameter may be a number or numeric expression which specifies the amount the loop counter is incremented for each pass through the loop. A negative value for *step_size* decrements the loop counter. The program segment is repeatedly executed until the loop counter exceeds the *final_value*.

```
10 OUTPUT 722; "SUB DMM_CONF"
20 OUTPUT 722; "NRDGS 100"
30 OUTPUT 722; "TRIG SGL"
40 OUTPUT 722; "INTEGER I"
50 OUTPUT 722; "FOR I = 1 TO 100"
60 OUTPUT 722; " ENTER A[ I]"
70 OUTPUT 722; "NEXT I"
80 OUTPUT 722; "SUBEND"
90 !
```

```
100 OUTPUT 722; "CALL DMM_CONF"
110 END
```

WHILE Loops

The WHILE command defines a loop which is repeated as long as the specified numeric expression is true. The syntax for the WHILE command is shown below.

WHILE *expression*

program segment

ENDWHILE

The WHILE operation depends on the result of a test performed at the start of the loop. If the test is true (not equal to zero), the program segment between the WHILE and ENDWHILE statements is executed and a branch is made back to the WHILE statement. If the test is false (equal to zero), program execution continues with the statement following the ENDWHILE statement.

```
10 OUTPUT 722; "SUB DMM_CONF"
20 OUTPUT 722; "INTEGER I"
30 OUTPUT 722; "LET I=1"
40 OUTPUT 722; "NRDGS 100"
50 OUTPUT 722; "TRIG SGL"
60 OUTPUT 722; "WHILE I <=100"
70 OUTPUT 722; " ENTER A[I]"
80 OUTPUT 722; " LET I=I+1"
90 OUTPUT 722; "ENDWHILE"
100 OUTPUT 722; "SUBEND"
110 !
120 OUTPUT 722; "CALL DMM_CONF"
130 END
```

IF...THEN Branching

The IF...THEN command provides conditional branching within 3458AA subprograms. The syntax statements for the IF...THEN command is shown below.

IF *expression* THEN

program segment

[ELSE]

[program segment]

ENDIF

The ENDIF statement must follow the IF...THEN statement somewhere in the subprogram. ELSE is an optional statement, but if used must appear before the ENDIF statement. All commands after the IF...THEN statement and before the ELSE and ENDIF statements will be executed if the expression evaluates to true (not equal to zero).

If the expression is true, execution continues with the program segment between IF...THEN and ELSE. If the expression is false, execution continues with the segment after ELSE. In either case, when the program segment is completed, assuming there are no other loops or conditional branches, program execution continues with the statement following the ENDIF statement.

```
10 OUTPUT 722; "SUB DMM_CONF"
20 OUTPUT 722; "INTEGER I"
30 OUTPUT 722; "LET I=1"
40 OUTPUT 722; "NRDGS 100"
50 OUTPUT 722; "TRIG SGL"
60 OUTPUT 722; "IF I<100 THEN"
70 OUTPUT 722; " ENTER A[I] "
80 OUTPUT 722; " LET 1=1+1"
90 OUTPUT 722; "ENDIF"
100 OUTPUT 722; "SUBEND"
110 !
120 OUTPUT 722; "CALL DMM_CONF"
130 END
```


A Specifications

For the specifications and characteristics of the 3458A multimeter, refer to the datasheet at <http://literature.cdn.keysight.com/litweb/pdf/5965-4971E.pdf>.

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B GPIB Commands

Introduction 412

Introduction

The BASIC language GPIB commands in this appendix are specifically for HP Series 200/300 computers. Any IEEE-488 controller can send these messages; however, the syntax may be different from that shown here. The IEEE-488 terminology is shown in parentheses following each command title. All syntax statements and examples assume an interface select code of 7 and the device address of 22. [Table B-1](#) shows the multimeter's GPIB capabilities.

Table B-1 GPIB capabilities

IEEE 488.1 function	Code	Description
Source handshake	SH1	Allows the multimeter to properly transfer multiline messages.
Acceptor handshake	AH1	Allows the multimeter to guarantee proper reception of multiline messages.
Talker	T5	Allows the multimeter to be a “talker” which means it can send data over the GPIB. This also allows the multimeter to respond to serial poll.
Listener	L4	Allows the multimeter to be a “listener” which enables it to receive information over the GPIB
Service request	SR1	Allows the multimeter to asynchronously send a service request to the controller.
Remote/Local	RL1	Allows the multimeter to be programmed over the GPIB or from its front panel.
Parallel poll	PPO	No capability.
Device clear	DC1	Allows the multimeter to be initialized to a cleared state by the Device Clear command issued from the controller.
Device trigger	DT1	Allows the multimeter to be triggered over the GPIB
Controller function	CO	No capability.
Driver electronics	E2	Describes the electrical drivers used by the multimeter (E2 = tri-state, 1MByte/second max.)

ABORT 7 (IFC)

Clears the multimeter's interface circuitry.

Syntax

ABORT 7

Example

```
ABORT 7          !CLEARS THE MULTIMETER'S INTERFACE CIRCUITRY
```

CLEAR (DCL or SDC)

Clears the multimeter, preparing it to receive a command. The CLEAR command does the following:

- Clears the output buffer.
- Clears the input buffer.
- Aborts subprogram execution.
- Clears the status register (bits 4, 5, and 6 are not cleared if the condition(s) that set the bit(s) still exist).
- Clears the display
- Disables triggering (the previous triggering mode can be resumed by sending any multimeter command).

Syntax

CLEAR 7

CLEAR 722

Examples

```
CLEAR 7          !CLEARS ALL DEVICES (DCL) ON THE BUS (SELECT CODE 7)
```

```
CLEAR 722       !CLEARS THE DEVICE (SDC) AT ADDRESS 22 (SELECT CODE 7)
```

LOCAL (GTL)

Removes the multimeter from the remote state and enables its keyboard (provided the keyboard has not been disabled with the multimeter's LOCK command).

Syntax

LOCAL 7
LOCAL 722

Remarks

- If the multimeter's LOCAL key is disabled by LOCAL LOCKOUT, the LOCAL 722 command enables the keyboard, but a subsequent remote command disables the keyboard. Sending the LOCAL 7 command, however, returns front panel control even after a subsequent remote message.

Examples

LOCAL 7 !SETS GPIB REN LINE FALSE (ALL DEVICES GO TO LOCAL). (YOU MUST NOW EXECUTE REMOTE 7 TO RETURN TO REMOTE MODE).

LOCAL 722 !ISSUES GPIB GTL TO DEVICE AT ADDRESS 22. (AFTERWARDS, EXECUTING ANY MULTIMETER COMMAND OR REMOTE 722 RETURNS THE MULTIMETER TO REMOTE MODE).

LOCAL LOCKOUT (LLO)

Disables the multimeter's LOCAL key.

Syntax

LOCAL LOCKOUT 7

Remarks

- If the multimeter is in the local state when you send LOCAL LOCKOUT, it remains in local. If the multimeter is in the remote state when you send LOCAL LOCKOUT, its LOCAL key and keyboard are disabled immediately.
- After disabling the LOCAL key with LOCAL LOCKOUT, you can only enable it by sending the GPIB LOCAL 7 command or by cycling power. If the multimeter's LOCAL key is disabled by LOCAL LOCKOUT, the LOCAL 722 command enables

the keyboard but a subsequent remote command disables it. Sending the LOCAL 7 command, however, enables the LOCAL key and keeps it enabled even after a subsequent remote message.

- If the multimeter's keyboard is disabled by both LOCAL LOCKOUT and the LOCK command, you must clear both to regain control of the keyboard. LOCAL LOCKOUT is cleared with the LOCAL command. LOCK is cleared by setting LOCK to OFF.

Examples

```
10 REMOTE 722 !SETS DEVICE AT ADDRESS 22 TO REMOTE STATE
20 LOCAL LOCKOUT 7 !SENDS LOCAL LOCKOUT (LLO) TO ALL
30 END !DEVICES ON THE BUS
```

REMOTE

Sets the GPIB REN line true.

Syntax

REMOTE 7
REMOTE 722

Remarks

- The REMOTE 722 command places the multimeter in the remote state. The REMOTE 7 command, does not. by itself. place the multimeter in the remote state. After sending the REMOTE 7 command, the multimeter will only go into the remote state when it receives its listen address.
- In most cases. you will only need the REMOTE command after using the LOCAL command. REMOTE is independent of any other GPIB activity and is sent on a single bus line called REN. Most controllers set the REN line true when power is applied or when reset.

Examples

```
REMOTE 7 !SETS GPIB REN LINE TRUE
```

The above line does not, by itself, place the multimeter in the remote state. The multimeter will only go into the remote state when it receives its listen address (e.g., sending OUTPUT 722;"BEEP").

REMOTE 722 !SETS REN LINE TRUE AND ADDRESSES DEVICE 22

The above line places the multimeter in the remote state.

SPOLL (Serial Poll)

The SPOLL command, like the STB? command (multimeter command set), returns a number representing the set bits in the status register (status byte). The returned number is the weighted sum of all set bits.

Syntax

P=SPOLL (722)

Status register bits

The bits and their corresponding weights are:

Bit number	Decimal weight	Description
0	1	Subprogram execution completed
1	2	Hi or lo limit exceeded
2	4	SRQ command executed
3	8	Power - on SRQ occurred
4	16	Ready for Instructions
5	32	Error (consult error register)
6	64	Service requested
7	128	Data available

Remarks

- If the SRQ line is set true when you send SPOLL, all bits in the status register are cleared provided the condition that set. the bit(s) is no longer present. If the SRQ line is false when you send SPOLL, the status register's contents are not changed.

- The SPOLL command differs from the STB? command in that STB? interrupts the multimeter's microprocessor. Thus, with STB? the multimeter always appears to be busy (bit 4 clear). SPOLL simply extracts the status byte without interrupting the microprocessor. Therefore, you can use SPOLL to monitor the readiness of the multimeter for further instructions.
- If data is in the output buffer when you send the SPOLL command, that data remains intact. If data is in the output buffer when you send the STB? command, however, the data is replaced by the status data.

Examples

```
10 P=SPOLL (722) !SENDS SERIAL POLL, PLACES RESPONSE INTO P
20 DISP P!DISPLAYS RESPONSE
30 END
```

TRIGGER (GET)

If triggering is armed (see TARM command), the TRIGGER command (Group Execute Trigger) triggers the multimeter once, and then holds triggering.

Syntax

TRIGGER 7
TRIGGER 722

Remarks

- The TRIGGER command generates a single trigger just as if the TRIG SGL command was executed. It will not, however, trigger the multimeter if triggering is not armed (TARM command).
- If subprogram memory execution is suspended by the PAUSE command (multimeter command set), the TRIGGER command resumes subprogram execution but does not generate a single trigger.

Examples

```
TRIGGER 7 !SENDS GROUP EXECUTE TRIGGER (GET)
TRIGGER 722 !SENDS GROUP EXECUTE TRIGGER (GET) TO THE DEVICE AT ADDRESS
22
```

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C Procedure to Lock Out Front/Rear Terminals and Guard Terminal Switches

Introduction	420
Tools Required	421
Procedure	422

Introduction

Either or both the Front/Rear Terminals and Guard Terminal switches can be locked out to prevent changing their settings. To do this, first remove all covers from the 3458A. Then, remove the pushrods from the Front/Rear and Guard switches. Next, place switch covers over the holes where the pushrods previously protruded through. The switch covers are in the Front/Rear Terminal and Guard Switch Lockout kit. Last, reinstall the instrument covers.

WARNING

The following procedures are to be performed by qualified service-trained personnel only. To avoid personal injury, do not perform the procedures unless you are qualified to do so.

Tools Required

You need:

- 1** #1 Pozidriv screwdriver
- 2** #TX 15 Torx driver
- 3** #TX10 Torx driver

Procedure

The procedure to install the lockout kit is separated into the following:

- Covers Removal Procedure
- Guard Pushrod Removal Procedure
- Front/Rear Pushrod Removal Procedure
- Switch Cap Installation Procedure
- Covers Installation Procedure

Covers removal procedure

Do the following:

- 1** Remove any connections to the 3458A.
- 2** Remove ac power from the 3458A.
- 3** Refer to [Figure C-1](#). Turn the instrument so its right side faces you (as seen from the front).

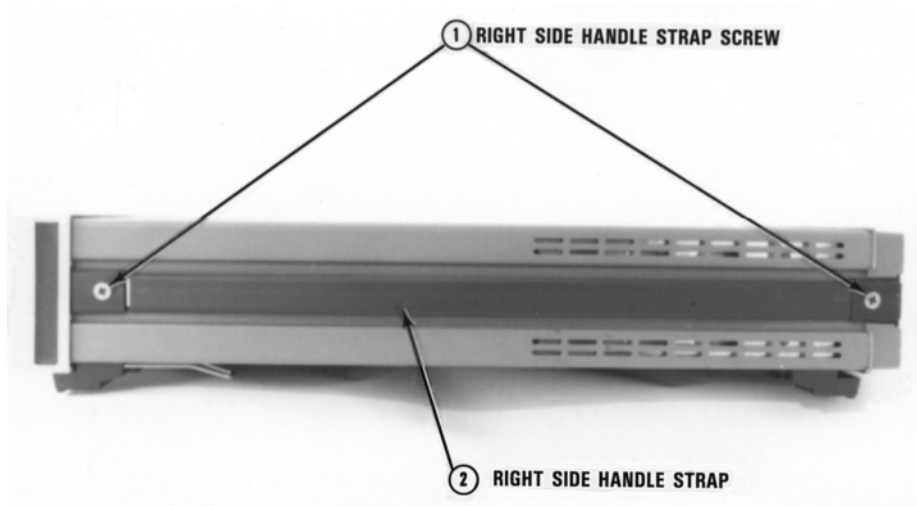


Figure C-1 3458A right side

- 4 Use the #1 Pozidriv to remove the right side handle strap screws. Then remove the strap.
- 5 Refer to **Figure C-2**. Turn the instrument so its left side faces you.
- 6 Use the #1 Pozidriv to remove the left side handle strap screws. Then remove the strap.
- 7 Use the #TX10 Torx driver to remove the top and bottom covers ground screws, as shown in **Figure C-3**.
- 8 Refer to **Figure C-4**. Turn the instrument so its back faces you.
- 9 Use the #TX15 Torx driver to remove the rear bezel screws. Then remove the rear bezel.
- 10 Remove the top cover. Pull the cover toward the rear and away from the instrument.
- 11 Turn the 3458A over so its top sits on your workbench. Remove the bottom cover. Pull the cover toward the rear and away from the instrument. Leave the instrument in its present position.

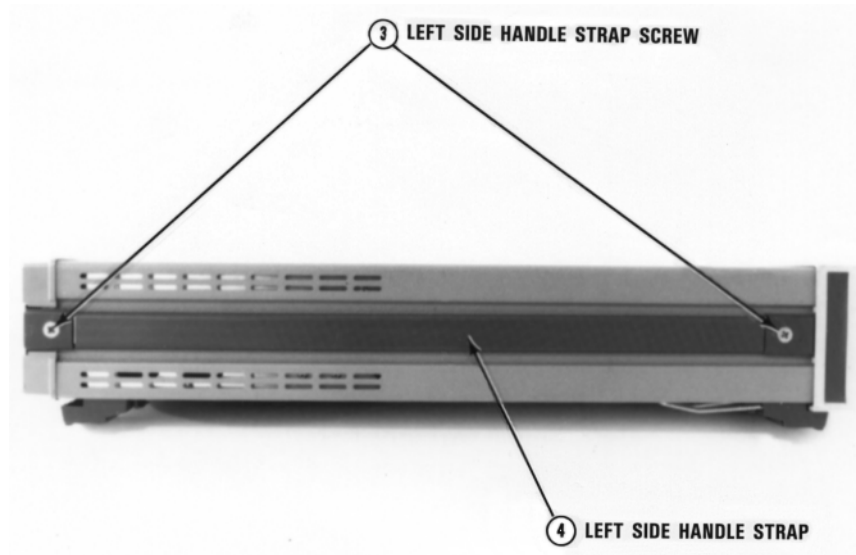


Figure C-2 3458A left side

C Procedure to Lock Out Front/Rear Terminals and Guard Terminal Switches

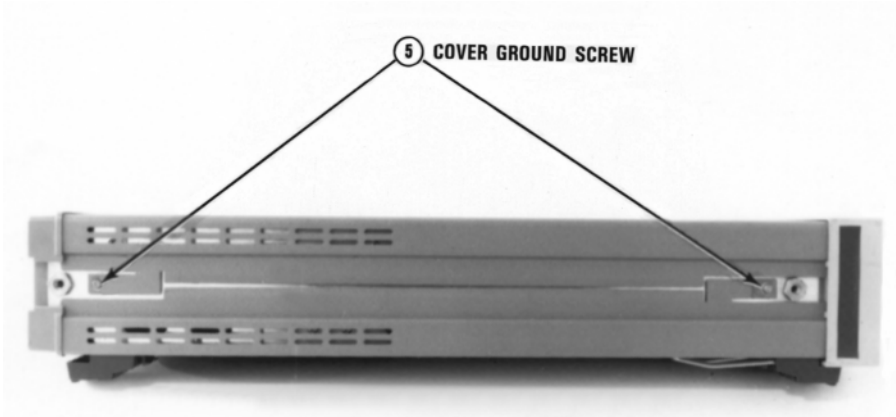


Figure C-3 Covers ground screws

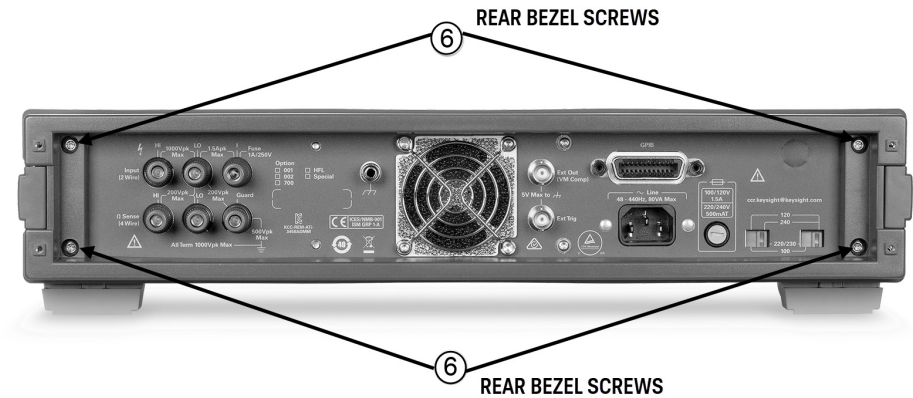


Figure C-4 3458A rear view

Guard pushrod removal procedure

If you DO NOT wish to lockout the Guard switch, continue with the next paragraph.

- 1** Refer to **Figure C-5**. Use the #TX 10 Torx driver to remove the bottom shield screw. Then remove the shield. Pull the shield toward the rear of the instrument until the shield retainers line up with the slots in the shield. Lift the shield off.
- 2** Refer to **Figure C-6**, Locate the pushrod for the Guard switch. Pull the pushrod off. You may need to pry the pushrod loose with a small flat blade screwdriver. Set the switch in the position it is to be used.
- 3** Refer to **Figure C-5**. Replace the bottom shield. Line up the slots on the shield with the shield retainers. Then push the shield toward the front of the instrument until the shield screw hole lines up with the screw hole in the chassis. Use the #TX 10 Torx driver to reinstall the shield screw.

Front/Rear pushrod removal procedure

If you DO NOT wish to lockout the Front/Rear Terminal switch, continue with the next paragraph.

- 1** Refer to **Figure C-7**. Turn the instrument over so its bottom sits on your work bench.
- 2** Use the #TX10 Torx driver to remove the top shield screw. Then remove the shield. Pull the shield toward the rear of the instrument until the shield retainers line up with the slots in the shield. Lift the shield off.

C Procedure to Lock Out Front/Rear Terminals and Guard Terminal Switches

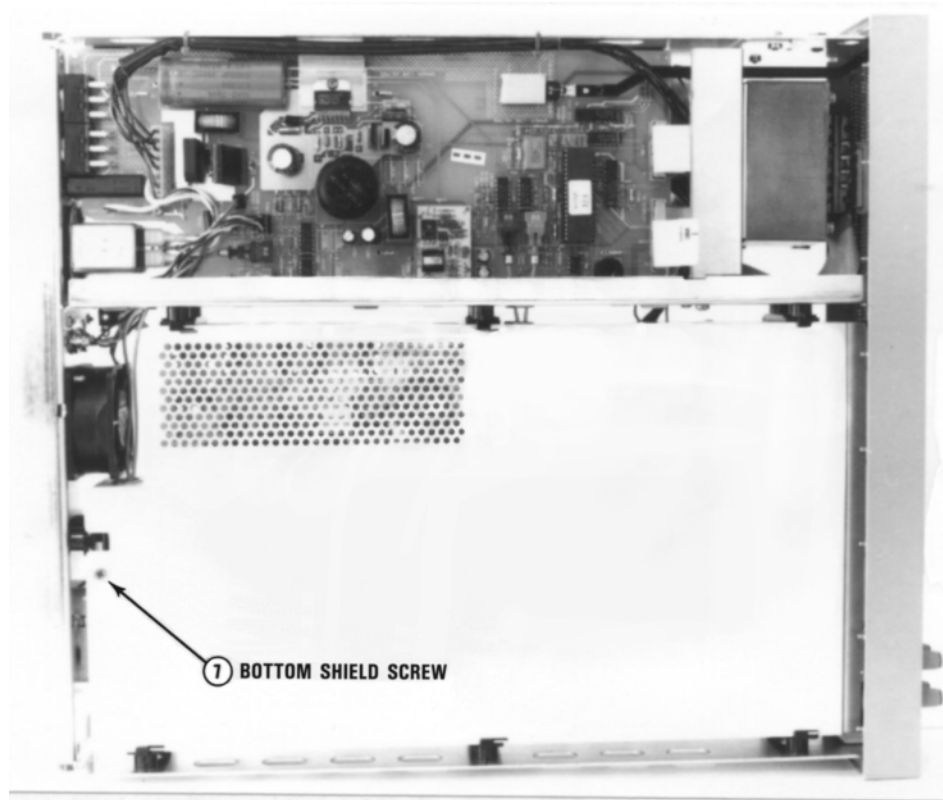


Figure C-5 3458A inside bottom view

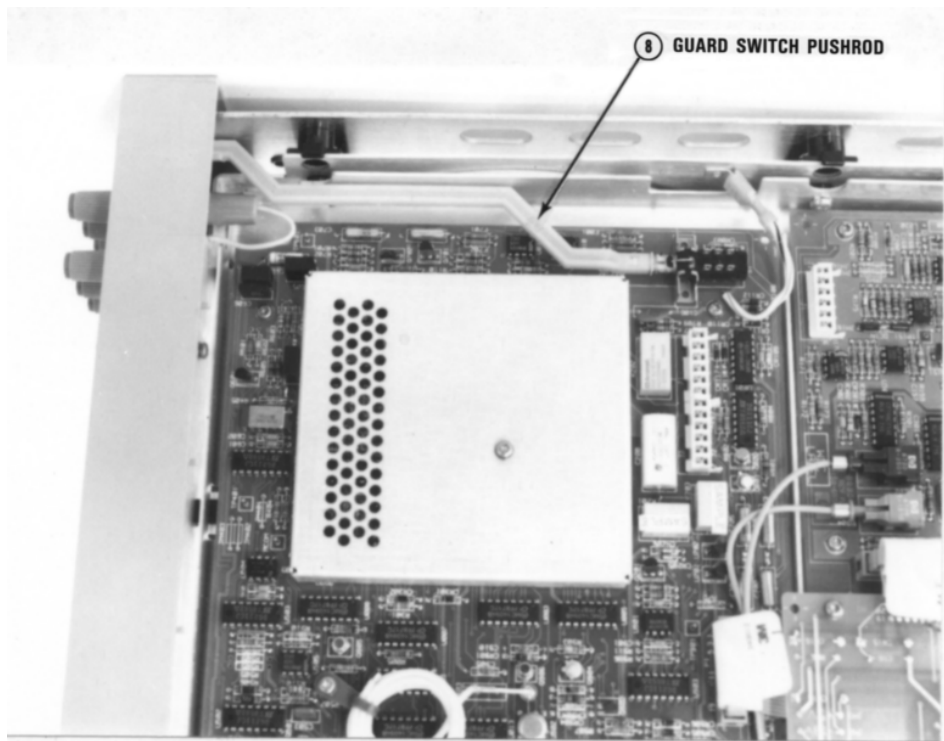


Figure C-6 Guard switch and pushrod location

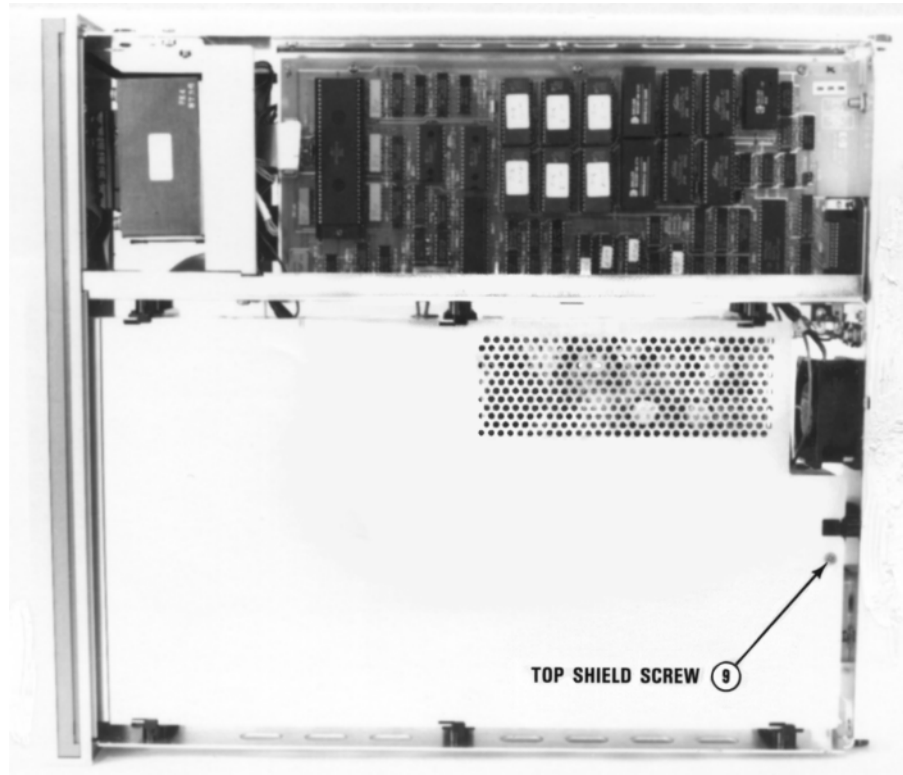


Figure C-7 3458A inside top view

- 3** Refer to **Figure C-8**. Locate the pushrod for the Front/Rear Terminal switch. Pull the pushrod off. You may need to pry the pushrod loose with a small flat blade screwdriver. Set the switch in the position it is to be used.
- 4** Refer to **Figure C-7**. Replace the top shield. Line up the slots on the shield with the shield retainers. Then push the shield toward the front of the instrument until the shield screw hole lines up with the hole in the chassis. Use the #TX 10 Torx driver to reinstall the shield screw.

Switch cap installation procedure

Do the following:

- 1 Refer to **Figure C-9**. Turn the instrument so its front faces you.
- 2 Locate the holes for the Front/Rear terminal and Guard switches.
- 3 Locate the little square covers that came in the switch lockout kit. as shown in **Figure C-9**.
- 4 Line up the tabs on the covers with the top and bottom sides of either the Front/Rear Terminal or Guard switch hole.
- 5 Squeeze the tabs on the cover together and push the cover all the way into the switch hole. Lock it in place.
- 6 Do the same in steps 4 and 5 for the other switch hole, if necessary.

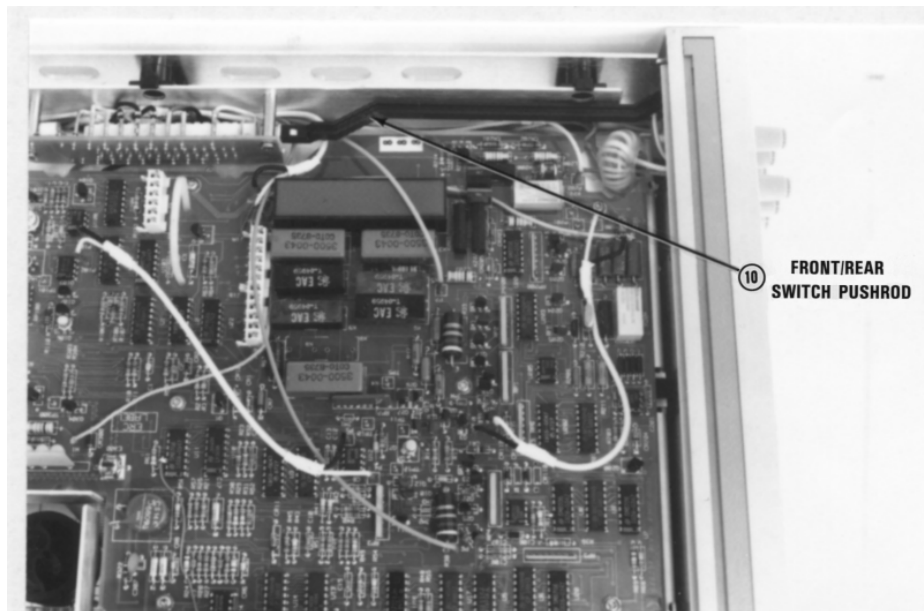


Figure C-8 Front/rear terminal switch and pushrod location

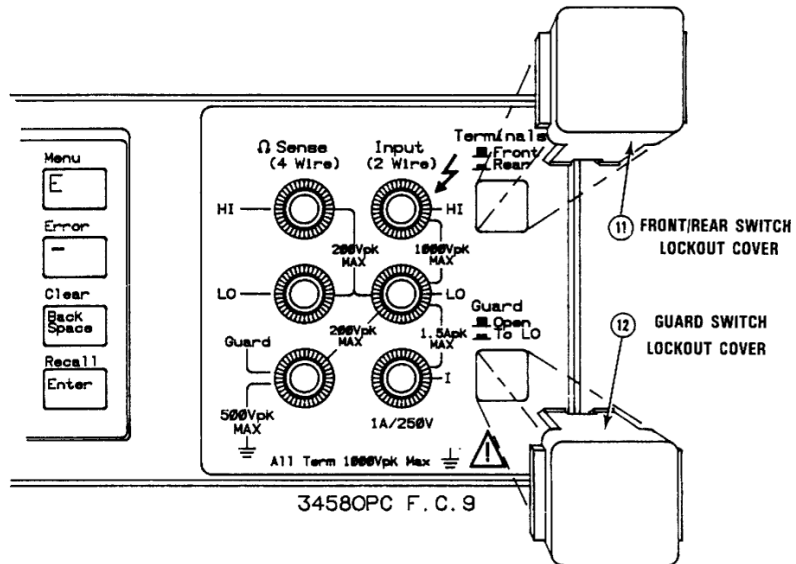


Figure C-9 Switch covers installation

Covers installation procedure

Do the following:

- 1 Turn the 3458A over so its top sits on your workbench.
- 2 Install the bottom cover by placing it into the slots of the instrument side castings, Then push the cover toward the front of the instrument into the front panel bezel.
- 3 Turn the 3458A over so the bottom sits on your workbench.
- 4 Install the top cover by placing it into the slots of the instrument side castings. Then push the cover toward the front of the instrument into the front panel bezel.
- 5 Refer to [Figure C-4](#). Turn the instrument so its back faces you.
- 6 Reinstall the rear bezel. Use the #TX15 Torx driver to reinstall the rear bezel screws.

- 7 Refer to [Figure C-3](#). Turn the instrument so its left side faces you. Use the #TX10 Torx driver to reinstall the top and bottom covers ground screws.

WARNING

For safety purposes and proper operation, it is very imperative that the cover grounding screws be reinstalled.

- 8 Refer to [Figure C-2](#). Reinstall the left side handle strap. Use the #1 Pozidriv to reinstall side handle strap screws.
- 9 Refer to [Figure C-1](#). Turn the instrument so its right side faces you.
- 10 Reinstall the right side handle strap. Use the #1 Pozidriv to reinstall side handle strap screws.
- 11 Your instrument is now ready for use. Keysight suggests that after you apply power that you perform an automatic calibration on the instrument. To do this, use the “ACAL ALL” command.

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D

Optimizing Throughout and Reading Rate

Introducing the 3458A	434
Maximizing the Testing Speed	435
Purpose	437
DC Volts, DC Current and Resistance	438
AC Volts and AC Current	445
Optimizing the Testing Process Through Task Allocation	449
A Benchmark	452

(From Product Note 3458A-1)

In the past decade and a half, microcomputers have greatly improved both their internal speed and their speed of communication with other equipment. The actual clock rates of microcomputers used in instrumentation has gone from under 1 MHz to over 12 MHz and the data bus has gone from 8 bits to 16 bits.

During this same time period, the system multimeter has undergone an even more remarkable evolution in terms of both its speed of operation and its reading rate. In 1975, 24 readings per second with 5 1/2 digits of resolution was considered very fast; today the 3458A multimeter can make 50,000 readings per second with 5 1/2 digits-- two thousand times faster. This extraordinary increase in speed is attributable not simply to faster microcomputers, but to advances in the analog to digital conversion process, a better utilization of the microcomputer, and a better understanding of the application needs of the system user.

Introducing the 3458A

The 3458A multimeter now has reading rates from 4 1/2 digit DC Volts measurements at 100,000 per second, to 8 1/2 digit DC Volts measurements at 6 per second, or anywhere in between with a trade-off of less speed for more resolution. Even the traditionally slower measurement functions, such as AC Volts, are quicker with the 3458A. For example, you can measure true rms ACV at up to 50 readings per second with full accuracy for input frequencies greater than 10 kHz. That a multimeter's increased reading rate results in increased test throughput is clear. Not as obvious, but strongly affecting throughput as well, is the operating speed of the multimeter when changing function, range, reading speed (integration time), or interfacing mode. The 3458A can change function and range, take a measurement, and output the result at 200 per second.

Application oriented command language

Attempts to make measurement more application oriented and less hardware dependent resulted in advances in the command language of multimeters that often yielded easier, more friendly programming. However, these advances also required increased overhead and slower response to the command language. The 3458A multimeter has been specifically designed to overcome this problem by offering fast command response with an application-oriented command language that is also easy to use.

Intrinsically slow measurements

It is well known that some measurements are inherently not amenable to fast treatment. Examples of these are high impedance measurements, frequency measurements of low frequency events, root mean square (rms) AC voltage and current measurements, and accurate measurements in the presence of noise. Nonetheless, despite their inherent slowness, substantial increases in throughput can be achieved in test system requiring these measurements. The 3458A provides this improved throughput by offering a wide range of alternatives that can improve the speed of testing. For example, in many systems accuracy can be traded for speed; or flexibility in timing the measurement can lead to real increases in the rate of rms AC measurements with good accuracy. The set of trade-offs one may make with the 3458A multimeter is covered in detail in this Product Note.

Maximizing the Testing Speed

Program memory

The speed of the testing process can also be maximized by tailoring the communication path between the 3458A and the computer. The dmm is generally the fastest instrument in the system; hence to perform a series of measurements, the computer may be compelled to take more time with other instruments. Several features of the 3458A multimeter allow the allocation of measurement tasks to be split optimally between the computer and the dmm. Its unique, non-volatile Program Memory allows sequences of measurement to be performed dynamically using external events such as external, auxiliary, or GPIB^[1] triggers to step through the measurement sequence. In addition, using Program Memory, complete measurement sequences can be programmed and initiated from the front panel for standalone operation without a controller.

State storage

State Storage permits a static instrument state to be totally defined and recalled from memory with a simple program command. In addition, the 3458A transfers high-speed measurement data over GPIB or into and out its standard 10,000 (or optional 75,000) Reading Memory at 100,000 readings per second.

Reading analysis

Additional flexibility is provided by the 3458A's capability to perform data analysis internally to speed throughput and still give you the data you need for statistical quality control or for simple limit checking. Program Memory can perform the pass/fail math function and alert the computer to out-of-limits measurements with an interrupt flag. Alternatively, the many available math functions may be used to post-process the data acquired in memory, without loss of the maximum reading rate. These include statistical functions (mean, standard deviation, maximum, minimum, number of readings), dB and dBm, thermistor linearization, RTD linearization, scale, filter functions, and others. The choice of whether to perform data analysis in the computer or in the dmm depends on the testing task

[1] GPIB is an implementation of the IEEE Standard 488 and the identical ANSI Standard MC1.1 "Digital interface for programmable instrumentation".

and the convenience offered to the user by having these analysis functions available with a simple programming command.

Task grouping and sequence

Further gains in test throughput can be obtained by tailoring the measurement sequence to group similar measurements together, thus minimizing the number of instrument configuration changes between measurements. Custom programs written without the aid of automatic program generators can be so structured. Program generators are usually optimized for ease of programming and offer a simplistic approach to the testing task that lets you choose limits for each group of tests but do not necessarily group the tests for the fastest throughput. Functional test management software like the FTM300 allows the tests to be customized for throughput and still provides 70% of the overhead programming like Statistical Quality Control (SQC) and inventory management.

System uptime

Longer system up-time also means higher test system throughput. The 3458A multimeter performs a complete self-calibration of all functions, including AC, using high-stability internal standards. This self- or auto-calibration eliminates measurement errors due to time drift or temperature changes in your rack or on your bench for superior accuracy. When it's time for periodic calibration to external standards, simply connect a precision 10 V DC source and a precision 10 k Ω resistor. All ranges and functions, including AC, are automatically calibrated using precision internal ratio transfer measurements relative to the external standards. (The subject of calibration is treated in detail in Product Note 3458A-3)

A system's up-time is also increased as a result of the increased reliability of its components. the 3458A's reliability is a product of Keysight's "10 X" program of defect reduction. Through environmental, abuse, and stress testing during the design stages of product development, Keysight has reduced the number of defects and early failure in its instruments by a factor of ten over the past ten years.

Purpose

The purpose of this Product note is to illustrate how you can use the revolutionary speed and accuracy of the 3458A multimeter to achieve the best possible test throughput and reading rates for your application. This is achieved by providing an explanation of the trade-offs offered by the instrument, and its optimal use with the HP 9000 Series 200/300 computers.

Topics covered in the product note include:

- DC measurements (Volts, current, ohms) - the available trade-offs of speed, resolution, and accuracy for their optimal use in your test system.
- AC measurements (analog ACV, synchronous ACV, random ACV, current) - choosing the best mode and specifications for your application.
- frequency and period - selecting gate time to achieve desired speed, accuracy, or resolution.
- optimizing the testing process through task allocation - using built-in math functions or post-processed math, the readings memory, states memory, and Program Memory to best organize and allocate tasks between the dmm and the computer, with program examples.
- benchmarks with properly structured programs for maximum throughput using pass-fail limit checking and statistics.

DC Volts, DC Current and Resistance

The 3458A offers two separate measurement paths: the standard DCV path direct to the Analog to Digital Converter and a path to the track-and hold circuit (track-and-hold path). The DCV path is limited to 150 kHz bandwidth, the track-and-hold path can accept signals up to 12 MHz. The track-and-hold path is limited to 16 bits of resolution unless repeated measurements are made. The DCV path can present up to 8 1/2 digits (27 bits) resolution.

Optimizing through the DCV path

The classic trade-offs one can make with the 3458A are measurement speed versus measurement resolution. Because of early design decisions to reduce the intrinsic Johnson noise associated with real resistive components in the input path of the 3458A, the resolution of the integrated measurement is 3 times better than with dmms of previous generations. For example, with the 3457A one may make a 6 1/2 digit (3,000,000 count) measurement with one power line cycle of integration (PLC) or 17 ms; with the equivalent integration period, the 3458A may make a 7 1/2 digit measurement (12,000,000 counts). Similarly, extreme care is taken to insure the linearity is excellent, a factor of 10 times better than the 3457A. The result is faster, more accurate measurements than ever before. It also means that one can take advantage of the increased accuracy and resolution and make measurements at 1 PLC with the 3458A that previously would have taken 10 PLC.

For the measurement that requires only high speed, or a trade-off of resolution and accuracy without line noise as an issue, the 3458A provides a range of alternatives from 4 1/2 digits at 500 nanoseconds aperture to 8 1/2 digits at 1 seconds aperture and anywhere in between in 100 nanosecond steps. [Figure D-1](#) shows the aperture versus measurement speed, noise, resolution and accuracy.

From the graph in [Figure D-1](#), one can see the influence of the actual aperture or integration period on reading rate; hidden is the influence of the HPML commands on throughput and some of the basic operating methods of the 3458A. HPML is an application-oriented command set. The basic philosophy behind this command set is that you don't need know what the 3458A is doing to make the measurement but need only to understand the measurement you want to make. To optimize throughput for any complex application, however, requires more understanding of the operation of the 3458A than simply to make a measurement. Many of the trade-offs you will make involve trading speed for accuracy and

convenience. The HPML commands that most affect the throughput speed from a measurement viewpoint are:

```
FUNC<DCV, DCI, OHM, FOHM>,<range>,<resolution in %>
NPLC #
APER<integration period s>
RES <resolution in %>
AZERO,<on or off>
```

In [Table D-1](#) you'll see that NPLC and APER commands are somewhat interchangeable. The significant difference between these two commands is that NPLC actually uses the power line frequency to establish the integration period for the chosen multiple or submultiple of the line frequency. The APER command sets the integration period in fundamental units of seconds from 500 ns to 1 s in 100 ns steps. Operating at 60 Hz line frequency, for example, the choice of NPLC 1 is equal to APER 0.016666.

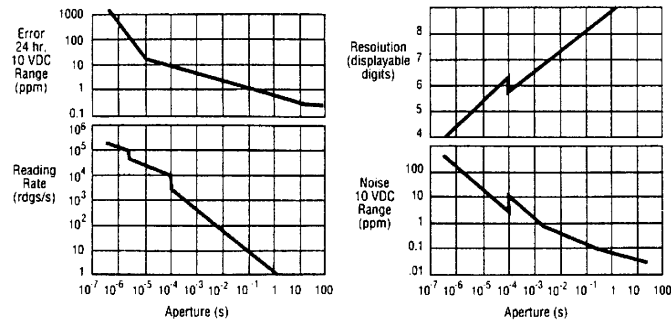


Figure D-1 Shows the dependency of accuracy, reading rate, resolution, and noise on aperture or NPLC selected

Table D-1 Integration time and query response

Command	Integration time (APER)		Query response (NPLC?)	
	50 Hz	60 Hz	50 Hz	60 Hz
NPLC0	500 ns	500 ns	25 E-6	29.99994 E-6
NPLC.5	10 ms	8.333 ms	500 E-3	499.99700 E-3
NPLC 1	20 ms	16.6667 ms	1	1
NPLC10	200 ms	166.667 ms	10	10
NPLC 11 ^[a]	200 ms	166.667 ms	20	20

[a] For NPLC > 10, the continuous integration period is equal to the integration period of NPLC 10, but more than one reading is taken. The resulting average is output to the display or to the GPIB.

If NPLC is in the interval from 1 to 10, inclusive, then the NPLC is rounded up to the next integer. If NPLC > 10, then the actual value of NPLC is rounded up to the next integer multiple of 10. For values of NPLC <1, the value selected is used much the same as aperture except that the integration period is scaled in terms of the line frequency. For example, if the value selected for NPLC is .1 PLC, the 3458A actually sets the integration period to .1X (line period to the nearest 100 ns) or .0016666 s (60 Hz operation). The query NPLC? returns 99.9958E-3 PLC. If the value of 2.5 is selected for NPLC, then the 3458A sets the integration period to 3 PLC. If the value of 21 is selected for NPLC, then the integration period is set to 30 PLC. NPLC 0 always selects the shortest integration period possible, 500 ns or 29.99994E-6 PLC(60 HZ operation).

Another command that affects the integration period is the resolution command, RES, which selects the number of digits of the reading displayed as a function of a percentage of the maximum input parameter. The resolution of the measurement is selected as a part of the function command or as the RES command. It sets the integration period to a value that will allow the ADC to convert the measurement to the resolution requested.

For example,

`DCV,20,.001` !(using the resolution parameter of this command)

and

`DCV,20;RES.001`

(omitting the resolution parameter of the DCV command and using the RES command) both set the 3458A to DCV, the 100 V range, the integration period to 8 μ s, and set the resolution to .001% of 20 V. The reading rate can be doubled simply by turning the auto zero operation off. Auto zero on (AZERO,ON) is the default condition of the 3458A. In this condition, to eliminate any thermally generated offset voltage on the input of the 3458A, internally, the input is shorted and a measurement is made to establish the offset voltage. The measured DC offset is subtracted from the actual input voltage and presented to the output as the final answer. Hence, there are really two measurement cycles normally involved in one measurement. This procedure ensures the specified accuracy of the 3458A, but it can produce measurements only half as fast as just measuring the input voltage. In a thermally stable environment, very little reduction in accuracy over a short period of time (10 minutes or so) results from disabling this function. Hence, beyond reducing the integration period, AZERO OFF is the most significant command you may use to increase reading rate.

DC current

The same general discussion for measuring DCV applies to current. With the exception that the current input is a separate terminal, the command DCI is used the same way that DCV is used. The current measurement path is selected with a series armature relay instead of the faster reed relays of DC volts and Ohms; hence, switching between current and other functions will take more time (in the neighborhood of 30 to 40 ms) than between DCV and Ohms.

Resistance

Resistance measurements require more settling time than DCV measurements. Above 10 k Ω longer settling time is introduced to make sure that the first reading is correct within specified limits. Again, if you wish to compromise the accuracy of the first reading, the settling time associated with the higher resistance measurements may be defeated by using the default delay. Before you change the program's delay setting to a lesser value, experiment with the application to determine the optimum settling time. [Figure D-2](#) shows the general trend in increasing settling times as a function of increasing resistance for first reading right.

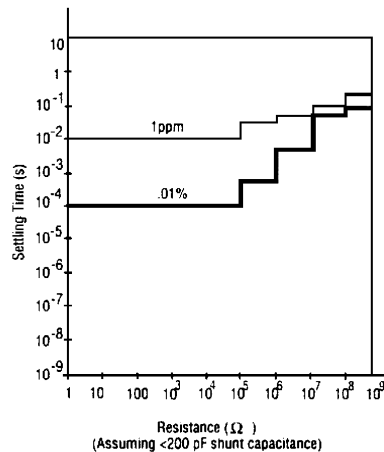
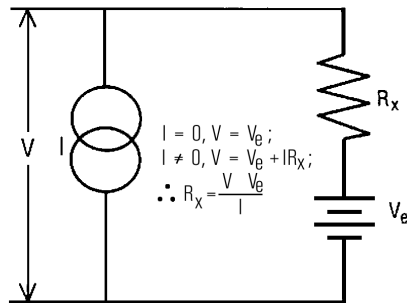


Figure D-2 Settling time characteristic for resistance measurements assuming <200 pF shunt capacitance in the circuit tested. For small values of resistance, there is no real advantage to setting the delay to less than the default values. Resistance above 100 k Ω require longer settling times to reach final values: hence settling delay times for these values may save measurement time at the expense of measurement accuracy.

Another feature of the 3458A is OffsetCompensated Ohms. Very much like auto zero in concept, offset-compensated Ohms makes a measurement of the input resistance without the current applied to measure any thermally generated DCV offsets. As shown in [Figure D-3](#), the current is applied, the offset voltage is subtracted from the measurement of the unknown resistance and the result is presented to the display. Like auto zero, it takes two measurements to make a final determination of the unknown resistance. In reality, offsets like this are only encountered in lower values of resistance. The 3458A offers a 10 mA current source that will, at least, mask the effect of the thermally generated offset. Hence, in many cases Offset-Compensated Ohms may not be needed for lower resistance measurements.

**Figure D-3**

Offset compensated ohms removes the effect of small series voltage sources such as thermocouple effects in the circuit. By measuring the voltage across the unknown resistance, V_e , with the current source off and then measuring the voltage across the unknown resistance with the current source on, the effect of V_e on the measurement is eliminated

Optimizing through the track-and-hold path (direct sampling and subsampling)

As stated earlier, the standard DCV path directs the signal to the A to D Converter. This path exhibits 150 kHz bandwidth and selectable resolution from 4 1/2 to 8 1/2 digits. The track-and- hold path exhibits 12 MHz bandwidth and 4 1/2 digits of resolution. This path uses a 16 bit track-and-hold circuit between the input and the A to D to take a "snapshot" of the input. DCV may be measured up to a maximum reading rate of 50,000 readings per second through this path. The commands for this choice of path are:

DSAC (direct sample, AC coupled)
 DSDC (direct sample, DC coupled)
 SSAC (subsampling, AC coupled)
 SSDC (subsampling, DC coupled)

D Optimizing Throughout and Reading Rate

The Product Note 3458A-2, High Resolution Digitizing with the 3458A System Multimeter, covers the use of these commands in detail along with their associated trigger commands and constraints. In general, the aspects of these commands that most influence throughput are those associated with ACV, where the 3458A handles the task of measuring the rms value of either repetitive wave forms with the synchronous ACV or noise measurements with random ACV. A detailed look at the techniques and the trade-offs of the three methods of rms ACV measurement is in the next section.

AC Volts and AC Current

The 3458A multimeter has the unique capability of offering the user three different ways of measuring equivalent DCV heating value of an input wave form (true root-mean-square value) : analog ACV, synchronous ACV and random ACV. The input signal follows the track-and-hold path (see [Figure D-4](#)) where it may be routed into the analog AC-to-DC converter or the track-and-hold circuit.

Analog ACV

The analog ACV offers broadband 10 Hz to 2 MHz rms capability utilizing a monolithic AC to DC converter. Its accuracy, while good, is not as good as the synchronous ACV's; its bandwidth, while also good, is not as good as the random or the synchronous ACV's. But, it does offer the ability to measure more accurately, faster than either of the other methods over its measurement bandwidth. And, it can measure either repetitive wave forms or noise signals.

Synchronous ACV

Synchronous ACV offers 1 Hz to 10 MHz bandwidth with excellent 100 ppm best accuracy, but the input wave form must be repetitive. The reading rate is determined by the frequency of the input wave form and the desired accuracy and resolution. The technique is straightforward: a frequency measurement is made on the input wave form, the decision to sample the input sequentially, or in bursts at 20 μ s intervals, is made based on the value of the frequency, and the measurements are processed statistically for the rms value. The number of samples taken, which is a measure of the speed, is determined by the resolution selected and also determines the accuracy of the measurement.

Random ACV

Random ACV offers the same upper measurement bandwidth that synchronous ACV offers, but the wave form can be noise or any non-repetitive signal. Since the resolution of the measurement is dependent upon the number of samples, this mode of operation is the least accurate and the slowest of the ACV functions for high resolution. Aliasing (discussed in detail in the Digitizing Product Note 3458A-2) is avoided by a random selection of sampling intervals from 20 to 40 μ s in 10 ns increments.

Comparison of ACV modes

With all three ACV modes of operation, the user has the option of selecting accuracy versus speed if the input frequency allows. Referring to [Table D-2](#), the frequency dependency of the reading rate is most pronounced for analog ACV: 1 reading per second from 10 Hz to 1 kHz, 10 readings per second from 1 kHz to 10 kHz, and 50 readings per second from 10 kHz to 2 MHz. These reading rates pertain to the specified accuracies for analog ACV. The reading rates of all three modes of operation can be increased by selecting either less resolution or by decreasing the delay time from the default times to a time interval of ten times the reciprocal of the highest frequency component present on the input signal. Hence, to capture a signal of 1 kHz, a delay time of at least 10 ms is needed for a representative measurement of the wave form.

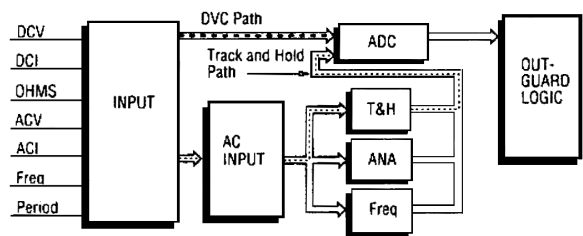


Figure D-4 Signal path block diagram offers three techniques for ACV measurement

Table D-2 Compares the ACV modes

	Analog	Synchronous	Random
Bandwidth	10 Hz to 2 MHz	1 Hz to 10 MHz	20 Hz to 10 MHz
Best Accuracy	300 ppm	100 ppm	1000 ppm
Reading Rate	50 rdgs/s	10 rdgs/s	40 rgds/s
Crest Factor	5:1	5:1	5:1
Waveforms	All	Repetitive	All

AC current

AC current measurements are made strictly through the analog ACV section with the voltage input being supplied by the DCI shunts. While there is no real decision to make regarding the mode of ACI measurement, you can decide to accept less accuracy and speed up the reading rate by decreasing the integration and settling time. As a rule of thumb, the AC to DC converter needs at least 10 cycles of the input wave form to give representative rms measurements. Hence, the frequency of the input has a direct impact on the reading rate. Characterization of the 3458A may be necessary to fine tune the measurement throughput for either ACV or ACI to fit your application.

Frequency and period

The track-and-hold path is also the route the signal must take for frequency and its reciprocal, period. The 3458A offers frequency response from 10 Hz to 10 MHz to 7½ digits with a maximum gate time of 1 second. One can trade speed for accuracy and resolution by selection of shorter gate times of the internal counter. [Table D-3](#) shows the trade-off of resolution for each of the gate times.

Table D-3 Shows resolution trade off for each of the gate times.

Gate time	Resolution	Reading rate
1 second	7 1/2 digit	1 rdgs/s
0.1 s	6 1/2	10 rdgs/s
0.01 s	5 1/2	73 rdgs/s
0.001 s	4 1/2	215 rdgs/s
0.0001 s	3 1/2	270 rdgs/s

After one has optimized each individual measurement in terms of the minimum time for the measurement with sufficient accuracy, there is yet another factor to consider to improve test throughput: task allocation. This factor involves the controlling computer and other instrumentation in the system. As stated in the introduction to this product note, for the most part, the fastest instrument in the test system is the dmm. Hence, its measurement rate may not be the throughput bottleneck in the system. One can take advantage the high-speed measurement

capability of the 3458A by letting it compute its own statistics, linearize its own thermistors, or check its own limits while the controller is controlling other instrumentation or is otherwise busy. The features of the 3458A dmm that make this possible are the built-in math functions, the Reading Memory, State Memory and Program Memory.

The time necessary to transfer measurements and commands to the computer is computer dependent. GPIB turnaround time, the time to process OUTPUT and ENTER operations will vary considerably from computer to computer. The features of Program Memory, Reading Memory, State Storage, and post-processing math operations all tend to decrease GPIB overhead and make the testing time far less computer dependent.

Optimizing the Testing Process Through Task Allocation

Math operations

Individually, math operations performed within the 3458A slow the measurement speed of the 3458A, but many times the combination of the 3458A with the controller will perform faster together to achieve final answers if the 3458A does some of the math itself. This is particularly true for pass/fail limit checking where the computer is alerted only if the test has failed. If statistics are important on the measurements, then it is a simple matter to let the 3458A assume the task of computation instead of having to write a program on the controller. The computer in the 3458A is a very powerful Motorola 68000 with a 8 MHz operating clock; therefore, many times it will have the same computational power that the controller has.

Data storage

The memory of the 3458A can be used to store measurements for later transfer to the controller for up to 10,000 readings (20 kBytes). Optionally, one may use the Option 001, Expanded Memory and get an additional 65,000 reading (128 kBytes) storage. The transfer rate into and out of the Reading Memory and the GPIB transfer rate using direct memory access with an HP 9000 Series 200/300 computer is 100,000 readings per second. The advantage of the memory is that one may access the data when it is convenient for the controller and not have to tie the system up waiting for the measurement to finish (a long integration period, a long settling time, or an average of multiple readings can cause even the fastest dmm to hold up the system).

Output formats

The 3458A offers five different data formats for both memory and GPIB output: single integer (SINT), double integer (DINT), IEEE-728 four byte single real (SREAL), IEEE-728 eight byte double real (DREAL), and ASCII. The fastest format for data transfer is the single integer. This is a 16 bit integer format so range information must be known to determine the placement of the decimal point. In addition, it only has 16 bits; hence, if more than 4 1/2 digits is desired from a measurement, one of the other formats must be used. The next highest speed format is double integer. This is a 32 bit integer format so, except for the range

information, all the measurement data is transferred. SREAL transfers all the data, including the range information, in four eight-bit bytes. The controller must be able to accept this format and translate it into ASCII to be able to use it. Finally, the slowest format is the ASCII format. Basically, each reading needs eighteen bytes of data plus carriage return/ line feed terminator to transfer into the controller. Many times it is important to acquire the data quickly but the actual transfer of the data can be comparatively slow. In this case, the ideal combination of data formatting is SREAL for measurements taken into memory and ASCII output to GPIB. The DINT and SINT formats are accepted directly without need for additional translation by the HP 9000 Series 200/300 computers. Almost any controller can accept ASCII formats.

In programs where functions or ranges are changed between measurement and the results are stored in the computer, it is probably best to lose a little speed and store the data in Reading Memory in either DREAL or SREAL. This avoids having to keep track of the scaling parameters needed for SINT and DINT.

State storage and program memory

A considerable savings in time at the right place in the testing task may be gained by the features of State Storage and Program Memory. State memory is used to establish a static state of the instrument with a single command transfer over GPIB. Initialization routines can set up the states that the programmer wishes to use in the test program during system dead time; then the state can be called at will.

Program Memory is dynamic memory. The state of the 3458A is dynamically changed as the sequence of operations programmed in Program Memory are stepped through as though the computer were controlling the sequence of events. The measurements taken can be stored in Reading Memory to be accessed at a convenient time either to be transferred in raw form to the computer or to be post processed in the 3458A. Again, once the command string is transferred to the memory of the 3458A, a simple command over GPIB initiates the measurement sequence. More important than the time saved by passing the simple command, the parsing routine of the 3458A actually compiles the Program Memory command string so that the measurement sequence can take place much faster than if the computer were controlling the operation. To ease some of the programming burden for lengthy set-ups, State Memory and other subprograms may be called from Program Memory.

Measurement list

The most efficient method of using the 3458A within a system is to establish a measurement list in Program Memory that corresponds with a channel list in the signal switching instrument. The 358A's External Output is connected to the Channel Advance input of the switching instrument and the Channel Closed output of the switching instrument is connected to the External Trigger input of the 3458A. Regardless of how long it takes to close a channel or make the measurement, the channel is always closed and the measurement is always had time for completion without programming additional WAIT statements or added delay. Further, the reduction in GPIB data messages results in faster, more convenient programming. In the [Figure D-5](#), the circuit is tested to show the interaction of the 3458A with a switching unit, the 3488A, using External Trigger and External Output. The measurements are simple AC and DC Volts and resistance. In this case, the time to change a function or a range is important to the test set-up because the channel closure is relatively slow (the 3488A uses very versatile, but slow armature relays with switching speeds of about 25 ms per channel closure); therefore, multiple measurements are made on a test point. If reed relays were used, it would be generally faster to change test points and stay on the same function if the test situation allowed.

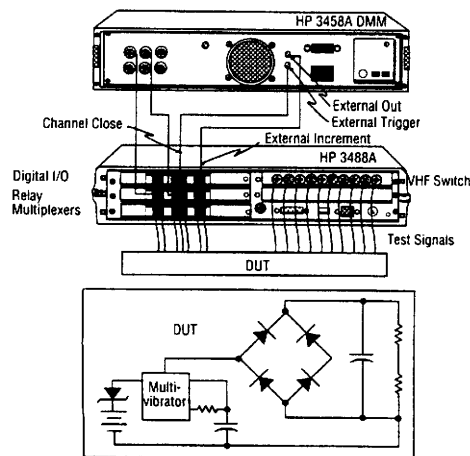


Figure D-5 Measurement list and scan list increase test throughput when used with External Increment tied to External Output and Channel close tied to external trigger

A Benchmark

The benchmark used to show the affect of the various functions of the 3458A multimeter will start with the most convenient, but least rapid, procedure of having the computer ask the dmm to change to a particular function, make a measurement, and transfer the measurement to the computer. The benchmark will assume that all of the measurements will be made through a FET scanner of infinitely fast switching speed and of infinite dynamic range. Hence, the benchmark represents an artificial situation, but one where the different modes of operation of the 3458A can be best illustrated. The computer used is the 9000 Series 200/300. Times for other computers will vary depending on the GPIB turnaround time of the computer. Results are shown in [Figure D-6](#).

The DUT contains:

25 resistance measurements

15 < 10 kOhm $\pm$ 5%

8 < 100 kOhm $\pm$ 5%

2 < 10 kOhm $\pm$.001%

10 DCV measurements

5 < 30 V $\pm$ 1%

4 < 10 V $\pm$.01 %

1 < 1 V $\pm$.001%

3 ACV measurements

1 < 250 V @ 50 Hz @ $\pm$ 5%

1 < 10 V @ 25 kHz @ $\pm$ 0.1%

1 < 1 V @ 5 kHz @ $\pm$ 0.075%

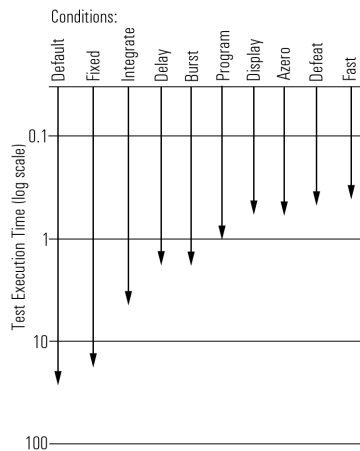


Figure D-6 Shows benchmark execution times for different configurations

The measurement sequence demands that the resistance values be checked before the circuit is powered. Then, the powerline voltage is checked for proper level. The output level 1 V at 5 kHz is checked to limits of $\pm 0.075\%$. Finally, the remaining voltages are checked in the following sequence:

- 2 DCV <10 V $\pm 1\%$
- 1 DCV <10 V $\pm 0.01\%$
- 2 DCV <10 V $\pm 1\%$
- 1 DCV <1 V $\pm 0.001\%$
- 1 ACV <10 V $\pm 1\%$
- 1 DCV <10 V $\pm 1\%$
- 3 DCV <10 V $\pm 0.01\%$

Benchmark results

Default conditions: (Subprogram Default) time = 20.63 s.

```

560 SUB Default(REAL Dnld_time,Exe_time,Tns_time)
570 DIM A(37)
580 Exe_time=TIMEDATE
590 OUTPUT 722;"RESET;TRIG SYN"
600 OUTPUT 722;"OHM"
610 FOR I=1 TO 23
620 ENTER 722;A(1)
630 NEXT I
640 OUTPUT 722;"OHMF"
...
780 ENTER 722;A(I)
790 NEXT I
800 Exe_time=TIMEDATE-Exe_time
810 Dnld_time=0
820 Tns_time=0
830 SUBEND

```

The 3458A is placed in remote operation by the computer and is reset to its default conditions. The integration time is set to 10 PLC, the settling delays are set so that first reading after a function or a range change meets its specified accuracy. Auto range is on. The computer asks the dmm to change range, or function, or integration time for 10 of the 37 measurements. The others are measured in blocks in the same measurement configuration.

Fixed range: (Subprogram Fixed) time = 15.98 s.

```

840 SUB Fixed(REAL Dnld_time,Exe_time,Tns_time)
850 DIM A(37)
860 Exe_time=TIMEDATE
870 OUTPUT 722;"RESET;TRIG SYN"
880 OUTPUT 722;"OHM,1E4"
890 FOR I=1 TO 15
900 ENTER 722;A(I)
910 NEXT I
920 OUTPUT 722;"OHM,1E5"
...
1110 ENTER 722;A(I)
1120 NEXT I
1130 Exe_time=TIMEDATE-Exe_time

```

```

1140 Dnld_time=0
1150 Tns_time=0
1160 SUBEND

```

The test situation is the same as the default situation but the ranges are set to the range necessary for the measurement instead of auto range.

Correct integration time: (Subprogram Integrate) time= 3.76 s.

```

1170 SUB Integrat(REAL Dnld_time,Exe_time,Tns_time)
1180 DIM A(37)
1190 Exe_time=TIMEDATE
1200 OUTPUT 722;"PRESET"
1210 OUTPUT 722;"OHM,1E4;NPLC 0"
1220 FOR I=1 TO 15
1230 ENTER 722;A(I)
1240 NEXT I
1250 OUTPUT 722;"OHM,1E5"

```

...

```

1410 ENTER 722;A(34)
1420 OUTPUT 722;"DCV,10;NPLC 0"
1430 FOR I=35 TO 37
1440 ENTER 722;A(I)
1450 NEXT I
1460 Exe_time=TIMEDATE-Exe_time
1470 Dnld_time=0
1480 Tns_time=0
1490 SUBEND

```

The test situation is the same as the fixed range situation, but the integration time selected for each measurement is correct for the required resolution and accuracy instead of the default of 10PLC.

Correct delay time: (Subprogram Delay) time = 1.48 s.

```

1500 SUB Delay(REAL Dnld_time,Exe_time,Tns_time)
1510 DIM A(37)
1520 Exe_time=TIMEDATE
1530 OUTPUT 722;"PRESET"
1540 OUTPUT 722;"OHM,1E4;NPLC 0;DELAY 0"
1550 FOR I=1 TO 15

```

...

```

1730 OUTPUT 722;"ACV,10;ACBAND 5000;APER 20E-6;DELAY .01"
1740 ENTER 722;A(34)

```

```

1750 OUTPUT 722;"DCV,10;NPLC 0;DELAY 0"
1760 FOR I=35 TO 37
1770 ENTER 722;A(I)
1780 NEXT I
1790 Exe_time=TIMEDATE-Exe_time
1800 Dnld_time=0
1810 Tns_time=0
1820 SUBEND

```

The test situation is the same as the situation with correct integration time, but now the delay time is set to a value that will produce measurements to the desired accuracy of each measurement instead of the default delays.

Using reading memory: (Subprogram Burst)

test execution time = 1.42 s

reading transfer time = .18 s

```

1830 SUB Burst(REAL Dnld_time,Exe_time,Tns_time)
1840 DIM A(37)
1850 Exe_time=TIMEDATE
1860 OUTPUT 722;"PRESET;MEM FIFO;MFORMAT SREAL
1870 OUTPUT 722;"OHM,1E4;NPLC 0;DELAY 0;NRDGS 15;TRIG SGL
1880 OUTPUT 722;"OHM,1E5;NRDGS 8;TRIG SGL
...
1940 OUTPUT 722;"DCV,10;NPLC 0;DELAY 0;NRDGS 3;TRIG SGL
1950 Exe_time=TIMEDATE-Exe_time
1960 Dnld_time=0
1970 Tns_time=TIMEDATE
1980 FOR I=1 TO 37
1990 ENTER 722;A(I)
2000 NEXT I
2010 Tns_time=TIMEDATE-Tns_time
2020 SUBEND

```

A marked change is effected in the structure of the program. Now the readings are stored in Reading Memory as the measurements are made. At the end of the measurement sequence, the readings are transferred from Reading Memory to the computer using a FOR NEXT loop. Except for the convenience of data transfer, there is no marked improvement in the speed of the measurement in this case. If the data were transferred via a TRANSFER statement to the computer, there would be more time savings.

Using program memory: (Subprogram Program)

test execution time = 1.06 s

program memory download time = .260 s

reading transfer time = .17 s

```

2030 SUB Program(REAL Dnld_time,Exe_time,Tns_time)
2040 DIM A(37)
2050 Dnld_time=TIMEDATE
2060 OUTPUT 722;"PRESET;MFORMAT SREAL"
2070 OUTPUT 722;"SUB 1;MEM FIFO;OHM,1E4;NPLC 0;DELAY0;NRDGS 15;TRIG
SGL"
2080 OUTPUT 722;"OHM,1E5;NRDGS 8;TRIG SGL"
2090 OUTPUT 722;"OHMF,1E3;APER 20E-6;DELAY-1;NRDGS 2;TRIG SGL
2100 OUTPUT 722;"ACV,250;ACBAND 250;DELAY.1;NRDGS 1;TRIG SGL"
2110 OUTPUT 722;"ACV 10;ACBAND 25000;DELAY .01;TRIG SGL
2120 OUTPUT 722;"DCV,10;NPLC 0;DELAY 0;NRDGS 6;TRIG SGL"
2130 OUTPUT 722;"ACV,10;ACBAND 5000;APER 20E-6;DELAY.01;NRDGS 1;TRIG
SGL
2140 OUTPUT 722;"DCV,10;NPLC 0;DELAY 0;NRDGS 3;TRIG SGL;SUBEND"
2150 Dnld_time=TIMEDATE-Dnld_time
2160 Exe_time=TIMEDATE
2170 OUTPUT 722;"CALL 1"
2180 Exe_time=TIMEDATE-Exe_time
2190 Tns_time=TIMEDATE
2200 FOR I=1 TO 37 2210ENTER 722:A(I)
2220 NEXT I
2230 Tns_time=TIMEDATE-Tns_time
2240 SUBEND
...

```

Again, the structure of the program is changed. Now the sequence of measurements with all of the variations imposed up to this point on each measurement is placed in a dmm subprogram SUB 1. The commands are transferred from the computer to the 3458A where they are compiled. Execution of the commands commence when the dmm subprogram is called with the CALL 1 command. The readings are transferred when the dmm subprogram is complete.

Note that the program halted while the dmm is completing this sequence. If continued program operation were wanted, the output statement to the dmm would be:

```
OUTPUT 722 USING "#,K"; "CALL 1"
```

By using the image “#,K”, the End-Of-Line (EOL) terminators are suppressed. When the 3458A receives the command without a terminator, it releases the computer so that the computer can continue the program while the 3458A continues with the operations it was requested to do. Note that the execution time for the benchmark is markedly less than just using Reading Memory.

Display off: (Subprogram Display)

test execution time = .500 s

program memory download time = .280 s

reading transfer time = .180 s

```
2250 SUB Disp(REAL Dnld_time,Exe_time,Tns_time)
2260 DIM A(37)
2270 Dnld_time=TIMEDATE
2280 OUTPUT 722;"PRESET;MFORMAT SREAL;DISP OFF,TESTING"
2290 OUTPUT 722;"SUB 1;MEM FIFO;OHM,1E4;NPLC 0;DELAY 0;NRDGS 15;TRIG
SGL"
2300 OUTPUT 722;"OHM,1E5;NRDGS 8;TRIG SGL"
2310 OUTPUT 722;"OHMF,1E3;APER 20E-6;DELAY -1 ;NRDGS 2;TRIG SGL"
...

```

This is the same program as the Subprogram Program, but the display is turned off. The test execution time is cut in half.

Azero off: (Subprogram Azero)

test execution time = .510 s

program memory download time = .280 s

reading transfer time = .180 s

This is the same program as the Subprogram Display, but Auto Zero is turned off. There is no real advantage in test of this type because the reading speed is so fast that there really isn't much difference between leaving auto Zero on or off. In some cases it may be faster when changing function or integration time to leave Auto Zero On.

Defeat on: (Subprogram Defeat)

test execution time = .470 s

program memory download time = .280 s

reading transfer time = .180 s

```
2690 SUB Defeat(REAL Dnld_time,Exe_time,Tns_time)
2700 DIM A(37)
2710 Dnld_time=TIMEDATE
2720 OUTPUT 722;"PRESET;DISP OFF,TESTING;MFORMAT SREAL;DEFEAT ON"
2730 OUTPUT 722;"SUB 1;MEM FIFO;OHM,1E4;NPLC 0;DELAY 0;NRDGS 15;TRIG

```

```
SGL"
2740 OUTPUT 722;"OHM,1E5;NRDGS 8;TRIG SGL"
```

This is the same program as the Subprogram Display, but the DEFEAT function is turned on. In this mode of operation, some of the overload detection and protection circuitry is defeated. If a voltage of greater than 300 V is detected, the defeat feature is turned off and the event is noted in the 3458A's memory. This feature allows faster function and range changes but should not be, as a matter of practice, abused.

Still faster

A considerable increase in throughput can be had if you use TRANSFER statements instead of OUTPUT and ENTER statements. Further, the juxtaposition of some commands improve the measurement speed. Notably, the sequence for DELAY and ACBAND when working with ACV can make a large difference in execution speed. The proper sequence is:

```
DELAY <#>;ACBAND <#,#>;ACV <range>.
```

If you want to change the default settling times when you change a function, always change the DELAY command first. It is also faster in many cases to remain on one integration time rather than change. For example, to get 6 1/2 digits resolution, the 3458A can be set to APER 10E-5 (100 μ s), where it can take almost 10,000 readings per second. If measurement calls for only a few measurements with this resolution and a greater number with less resolution, it still may be faster to leave the integration time at 100 μ s and take all the measurements there. It takes about 6 to 10 ms for the 3458A to change integration time. At about 10,000 readings per second, the 3458A can take one hundred 6 1/2 digit readings in that time.

This last program uses transfers and the proper command sequence to achieve the greatest possible throughput for the benchmark program.

Execution time = .360 s

Program Memory Download Time = .05 s

Reading Transfer time = .05 s

```
10 OPTION BASE 1
20 DIM Command$(1000) BUFFER
30 DIM A$(100), B$(100), C$(100), D$(100), E$(100),
    F$(100), G$(100), H$(100), I$(100), Set_up$(100)
```

```

40 INTEGER I,M
50 REAL Readings(37) BUFFER
60 ASSIGN @Dmm TO 722
70 ASSIGN @Buf_1 TO BUFFER Command$
80 ASSIGN @Buf_2 TO BUFFER Readings(*)
90 CLEAR 722
100 OUTPUT @Dmm;"RESET"
110 Set_up$="PRESET;MFORMAT SREAL;DEFEAT ON;APER 100E-6;DISP
    OFF,TESTING"
120 B$="SUB Try;MEM FIFO;DELAY 0;OHM,1E4;NRDGS 15;TRIG SGL;"
130 C$="OHM,1E5;NRDGS 8;TRIG SGL;"
140 D$="DELAY -1;OHMF,1E3;NRDGS 2;TRIG SGL;"
150 E$="DELAY .1;ACBAND 50;ACV 250;NRDGS 1;TRIG SGL;"
160 F$="DELAY .01;ACBAND 25000;ACV,10;TRIG SGL;"
170 G$="DELAY 0;DCV 10;NRDGS 6;TRIG SGL;"
180 H$="DELAY .01;ACBAND 5000;ACV 10;NRDGS 1; TRIG SGL;"
190 I$="DELAY 0;DCV 10;NRDGS 3;TRIG SGL;SUBEND"
200 Command$=B$&C$&D$&E$&F$&G$&H$&I$
210 Dnload:! Transfer commands to dmm
220 Dnld_time=TIMEDATE
230 OUTPUT @Dmm;Set_up$
240 TRANSFER @Buf_1 TO @Dmm
250 Dnld_time=TIMEDATE-Dnld_time
260 Execute: ! Dmm Execution time
270 Exe_time=TIMEDATE
280 OUTPUT @Dmm;"CALL Try"
290 Exe_time=TIMEDATE-Exe_time
300 Read:! Transfer the readings to the Computer
310 Tns_time=TIMEDATE
320 TRANSFER @Dmm TO @Buf_2

```



```

330 Tns_time=TIMEDATE-Tns_time
340 PRINT "DOWN LOAD TIME =";Dnld_time
350 PRINT "EXECUTION TIME =";Exe_time
360 PRINT "TRANSFER TIME = ";Tns_time
370 PRINT "TOTAL TIME= "; Dnld_time+Exe_time+Tns_time
380 END

10 ! Bench Mark Test
20 !
30 COM Dnld_trme.Exe_time,Tns_time
40 !
50 CALL Default(Dnld_time,Exe_time,Tns_time)
60 PRINT USING "36A.DD.DDD";"The execution time for default is
   ";Exe_time
70 PRINT
80 !
90 CALL Fixed(Dnld_time.Exe_time,Tns_time)
100 PRINT USING "38A.DD.DDD":"The execution time for fixed range is
    ";Exe_time
110 PRINT
120 !
130 CALL Integrat(Dnld_time,Exe_time,Tns_time)
140 PRINT USING "51A,DD.DDD";"The execution time for correct
    integration time is";Exe_time
150 PRINT
160 !
170 CALL Delay(Dnld_time,Exe_time,Tns_time)
180 PRINT USING "44A,DD.DDD";"The execution time for correct delay time
    is";Exe_time
190 PRINT
200 !
210 CALL Burst(Dnld_time,Exe_time,Tns_time)

```

```

220 PRINT USING "44A,DD.DDD";"The execution time for storing readings
    is";Exe_time
230 PRINT USING "44A,DD.DDD";"The transfer time using FOR NEXT is
    ";Tns_time
240 PRINT USING "44A,DD,DDD";"The total time for memory IS
    ";Exe_time+Tns_time
250 PRINT
260 !
270 CALL Program(Dnld_time,Exe_time,Tns_time)
280 PRINT USING "44A,DD.DDD";"The execution time for program memory is
    ";Exe_time
290 PRINT USING "44A,DD,DDD";"The download time for transferring the SUB
    is";Dnld_time
300 PRINT USING "44A,DD.DDD";"The transfer time using FOR NEXT is
    ";Tns_time
310 PRINT USING "44A,DD.DDD";"The total time for program memory
    is";Exe_time+Dnld_time+ Tns_time
320 PRINT
330 !
340 CALL Disp(Dnld_time,Exe_time,Tns_time)
350 PRINT USING "44A,DD.DDD";"The execution time for program memory is
    ";Exe_time
360 PRINT USING "44A,DD.DDD";"The download time for transferring the SUB
    is";Dnld_time
370 PRINT USING "44A,DD.DDD";"The transfer time using FOR NEXT is
    ";Tns_time
380 PRINT USING "44A,DD.DDD";"The total time for display off
    is";Exe_time+Dnld_time+Tns_time
390 PRINT
400 !
410 CALL Azero(Dnld_time,Exe_time,Tns_time)
420 PRINT USING "44A,DD.DDD";"The execution time for program memory is
    ";Exe_time

```

```

430 PRINT USING "44A,DD.DDD";"The download time for transferring the SUB
    is";Dnld_time
440 PRINT USING "44A,DD.DDD";"The transfer time using FOR NEXT is
    ";Tns_time
450 PRINT USING "44A,DD.DDD";"The total time for AZERO off is";
    Exe_time+Dnld_time+ Tns_time
460 PRINT
470 !
480 CALL Defeat(Dnld_time,Exe_time,Tns_time)
490 PRINT USING "44A,DD.DDD";"The execution time for program memory is
    ";Exe_time
500 PRINT USING "44A,DD.DDD";"The download time for transferring the SUB
    is";Dnld_time
510 PRINT USING "44A,DD.DDD";"The transfer time using FOR NEXT is
    ";Tns_time
520 PRINT USING "44A,DD.DDD";"The total time for DEFEAT ON
    is";Exe_time+Dnld_time+Tns_time
530 PRINT
540 !
550 END
560 SUB Default(REAL Dnld_time,Exe_time, Tns_time)
570 DIM A(37)
580 Exe_time=TIMEDATE
590 OUTPUT 722:"RESET;TRIG SYN"
600 OUTPUT 722;"OHM"
610 FOR I=1 TO 23
620 ENTER 722;A(I)
630 NEXT I
640 OUTPUT 722;"OHMF"
650 ENTER 722;A(24)
660 ENTER 722;A(25)
670 OUTPUT 722;"ACV"

```

```

680 ENTER 722;A(26)
690 ENTER 722;A(27)
700 OUTPUT 722;"DCV"
710 FOR I=28 TO 33
720 ENTER 722;A(I)
730 NEXT I
740 OUTPUT 722;"ACV"
750 ENTER 722;A(34)
760 OUTPUT 722;"DCV"
770 FOR I=35 TO 37
780 ENTER 722;A(I)
790 NEXT I
800 Exe_time=TIMEDATE-Exe_time
810 Dnld time=0
820 Tns_time=0
830 SUBEND
840 SUB Fixed(REAL Dnld_time,Exe_time,Tns_time)
850 DIM A(37)
860 Exe_time=TIMEDATE
870 OUTPUT 722;"RESET;TRIG SYN"
880 OUTPUT 722;"OHM,1E4"
890 FOR I=1 TO 15
900 ENTER 722;A(I)
910 NEXT I
920 OUTPUT 722;"OHM,1E5"
930 FOR I=16 TO 23
940 ENTER 722;A(I)
950 NEXT I
960 OUTPUT 722;"OHMF,1E3"
970 ENTER 722;A(24)

```

```
980 ENTER 722;A(25)
990 OUTPUT 722;"ACV,250;ACBAND 250"
1000 ENTER 722;A(26)
1010 OUTPUT 722;"ACV 10;ACBAND 25000"
1020 ENTER 722;A(27)
1030 OUTPUT 722;"DCV, 10"
1040 FOR I=28 TO 33
1050 ENTER 722;A(1)
1060 NEXT I
1070 OUTPUT 722;"ACV,10;ACBAND 5000"
1080 ENTER 722;A(34)
1090 OUTPUT 722;"DCV,10"
1100 FOR I=35 TO 37
1110 ENTER 722;A(I)
1120 NEXT I
1130 Exe_time=TIMEDATE-Exe_time
1140 Dnld time=0
1150 Tns_time=0
1160 SUBEND
1170 SUB Integrat(REAL Dnld_time,Exe_time, Tns_time)
1180 DIM A(37)
1190 Exe_time=TIMEDATE
1200 OUTPUT 722;"PRESET"
1210 OUTPUT 722;"OHM,1E4;NPLC 0"
1220 FOR I=1 TO 15
1230 ENTER 722;A(I)
1240 NEXT I
1250 OUTPUT 722;"OHM,1E5"
1260 FOR I=16 TO 23
1270 ENTER 722;A(1)
```

```

1280 NEXT I
1290 OUTPUT 722;"OHMF,1E3;APER 20E-6"
1300 ENTER 722;A(24)
1310 ENTER 722;A(25)
1320 OUTPUT 722;"ACV,250;ACBAND 250"
1330 ENTER 722;A(26)
1340 OUTPUT 722;"ACV 10;ACBAND 25000"
1350 ENTER 722;A(27)
1360 OUTPUT 722;"DCV,10;NPLC 0"
1370 FOR I=28 TO 33
1380 ENTER 722;A(I)
1390 NEXT I
1400 OUTPUT 722;"ACV,10;ACBAND 5000;APER 20E-6"
1410 ENTER 722;A(34)
1420 OUTPUT 722;"DCV,10;NPLC 0"
1430 FOR I=35 TO 37
1440 ENTER 722;A(I)
1450 NEXT I
1460 Exe_time=TIMEDATE-Exe_time
1470 Dnld_time=0
1480 Tns_time=0
1490 SUBEND
1500 SUB Delay(REAL Dnld_time,Exe_time,Tns_time)
1510 DIM A(37)
1520 Exe_time=TIMEDATE
1530 OUTPUT 722;"PRESET"
1540 OUTPUT 722;"OHM,1E4;NPLC 0;DELAY 0"
1550 FOR I=1 TO 15
1560 ENTER 722;A(I)
1570 NEXT I

```

```

1580 OUTPUT 722;"OHM,1E5"
1590 FOR I=16 TO 23
1600 ENTER 722;A(I)
1610 NEXT I
1620 OUTPUT 722;"OHMF,1E3;APER 20E-6;DELAY-1"
1630 ENTER 722;A(24)
1640 ENTER 722;A(25)
1650 OUTPUT 722;"ACV,250;ACBAND 250;DELAY.1"
1660 ENTER 722;A(26)
1670 OUTPUT 722;"ACV 10;ACBAND 25000;DELAY.01"
1680 ENTER 722;A(27)
1690 OUTPUT 722;"DCV,10;NPLC 0;DELAY 0"
1700 FOR I=28 TO 33
1710 ENTER 722;A(I)
1720 NEXT I
1730 OUTPUT 722;"ACV,10;ACBAND 5000;APER 20E-6; DELAY .01"
1740 ENTER 722;A(34)
1750 OUTPUT 722;"DCV,10;NPLC 0;DELAY 0"
1760 FOR I=35 TO 37
1770 ENTER 722;A(I)
1780 NEXT I
1790 Exe_tlme=TIMEDATE-Exe_time
1800 Dnld_time=0
1810 Tns_time=0
1820 SUBEND
1830 SUB Burst(REAL Dnld_time,Exe_time,Tns_time)
1840 DIM A(37)
1850 Exe_time=TIMEDATE
1860 OUTPUT 722;"PRESET;MEM FIFO;MFORMAT SREAL"
1870 OUTPUT 722;"OHM,1E4;NPLC 0;DELAY 0;NRDGS 15:TRIG SGL"

```

```

1880 OUTPUT 722:"OHM,1E5;NRDGS 8;TRIG SGL"
1890 OUTPUT 722;"OHMF,1E5;APER 20E-6;DELAY -1;NRDGS 2,TRIG SGL"
1900 OUTPUT 722;"ACV,250;ACBAND 250;DELAY.1;NRDGS 1;TRIG SGL"
1910 OUTPUT 722;"ACV 10;ACBAND 25000;DELAY.01;TRIG SGL"
1920 OUTPUT 722;"DCV,10;NPLC 0;DELAY 0;NRDGS 6;TRIG SGL"
1930 OUTPUT 722;"ACV,10;ACBAND 5000;APER 20E-6;DELAY .01;NRDGS 1;TRIG
    SGL"
1940 OUTPUT 722;"DCV,10;NPLC 0;DELAY 0;NRDGS 3;TRIG SGL"
1950 Exe_time=TIMEDATE-Exe_time
1960 Dnld_time=0
1970 Tns_time=TIMEDATE
1980 FOR I=1 TO 37
1990 ENTER 722:A(I)
2000 NEXT I
2010 Tns_time=TIMEDATE-Tns_time
2020 SUBEND
2030 SUB Program(REAL Dnld_time,Exe_time,Tns_time)
2040 DIM A(37)
2050 Dnld_time=TIMEDATE
2060 OUTPUT 722:"PRESET;MFORMAT SREAL"
2070 OUTPUT 722;"SUB 1:MEM FIFO;OHM.1E4;NPLC 0;DELAY 0;NRDGS 15;TRIG
    SGL"
2080 OUTPUT 722;"OHM.1E5;NRDGS 8;TRIG SGL"
2090 OUTPUT 722;"OHMF, 1E3;APER 20E-6;DELAY-1; NRDGS 2;TRIG SGL"
2100 OUTPUT 722;"ACV,250;ACBAND 250;DELAY.1;NRDGS 1; TRIG SGL"
2110 OUTPUT 722;"ACV10;ACBAND 25000;DELAY.01;TRIG SGL"
2120 OUTPUT 722;"DCV,10;NPLC 0;DELAY 0;NRDGS 6; TRIG SGL"
2130 OUTPUT 722;"ACV,10;ACBAND 5000;APER 20E-6; DELAY.01;NRDGS 1;TRIG
    SGL"
2140 OUTPUT 722;"DCV,10;NPLC 0;DELAY 0;NRDGS 3; TRIG SGL;SUBEND"
2150 Dnld_time=TIMEDATE-Dnld_time

```



```

2160 Exe_time=TIMEDATE
2170 OUTPUT 722;"CALL 1"
2180 Exe_time=TIMEDATE-Exe_time
2190 Tns_time=TIMEDATE
2200 FOR I=1 TO 37
2210 ENTER 722;A(I)
2220 NEXT I
2230 Tns_time=TIMEDATE-Tns_time
2240 SUBEND
2250 SUB Disp(REAL Dnld_time,Exe_time,Tns_time)
2260 DIM A(37)
2270 Dnld_time=TIMEDATE
2280 OUTPUT 722;"PRESET;MFORMAT SREAL;DISP OFF,TESTING"
2290 OUTPUT 722;"SUB 1;MEM FIFO;OHM,1E4;NPLC 0;DELAY 0;NRDGS 15;TRIG
    SGL"
2300 OUTPUT 722;"OHM,1E5;NRDGS 8;TRIG SGL"
2310 OUTPUT 722;"OHMF,1E3;APER 20E-6;DELAY -1;NRDGS 2;TRIG SGL"
2320 OUTPUT 722;"ACV,250;ACBAND 250;DELAY .1;NRDGS 1;TRIG SGL"
2330 OUTPUT 722;"ACV 10;ACBAND 25000;DELAY .01;TRIG SGL"
2340 OUTPUT 722;"DCV,10;NPLC 0;DELAY 0;NRDGS 6;TRIG SGL"
2350 OUTPUT 722;"ACV,10;ACBAND 5000;APER 20E-6;DELAY .01;NRDGS 1;TRIG
    SGL"
2360 OUTPUT 722;"DCV,10;NPLC 0;DELAY 0;NRDGS 3;TRIG SGL;SUBEND"
2370 Dnld_time=TIMEDATE-Dnld_time
2380 Exe_time=TIMEDATE
2390 OUTPUT 722;"CALL 1"
2400 Exe_time=TIMEDATE-Exe_time
2410 Tns_time=TIMEDATE
2420 FOR I=1 TO 37
2430 ENTER 722:A(I)
2440 NEXT I

```

```

2450 Tns_time=TIMEDATE-Tns_time
2460 SUBEND
2470 SUB Azero(REAL Dnld_time,Exe_time,Tns_time)
2480 DIM A(37)
2490 Dnld_time=TIMEDATE
2500 OUTPUT 722;"PRESET;MFORMAT SREAL;DISP OFF, TESTING;AZERO OFF"
2510 OUTPUT 722;"SUB 1;MEM FIFO;OHM,1E4;NPLC 0;DELAY 0;NRDGS 15;TRIG
    SGL"
2520 OUTPUT 722;"OHM,1E5;NRDGS 8;TRIG SGL"
2530 OUTPUT 722;"OHMF,1E3;APER 20E-6;DELAY-1; NRDGS 2;TRIG SGL"
2540 OUTPUT 722;"ACV,250;ACBAND 250;DELAY.1;NRDGS 1;TRIG SGL"
2550 OUTPUT 722;"ACV 10;ACBAND 25000;DELAY.01; TRIG SGL"
2560 OUTPUT 722;"DCV10;NPLC 0;DELAY 0;NRDGS 6; TRIG SGL"
2570 OUTPUT 722;"ACV,10;ACBAND 5000;APER 20E-6; DELAY.01;NRDGS 1;TRIG
    SGL"
2580 OUTPUT 722;"DCV,10;NPLC 0;DELAY 0;NRDGS 3; TRIG SGL;SUBEND"
2590 Dnld_time=TIMEDATE-Dnld_time
2600 Exe_time=TIMEDATE
2610 OUTPUT 722;"CALL 1"
2620 Exe_time=TIMEDATE-Exe_time
2630 Tns_tlme=TIMEDATE
2640 FOR I=1 TO 37
2650 ENTER 722;A(I)
2660 NEXT I
2670 Tns_time=TIMEDATE-Tns_time
2680 SUBEND
2690 Defeat(REAL Dnld_time,Exe_time,Tns_time)
2700 DIM A(37)
2710 Dnld_time=TIMEDATE
2720 OUTPUT 722;"PRESET;DISP OFF,TESTING;MFORMAT SREAL;DEFEAT ON"

```

```

2730 OUTPUT 722;"SUB 1;MEM FIFO;OHM.1E4;NPLC 0;DELAY 0;NRDGS 15;TRIG
    SGL"
2740 OUTPUT 722;"OHM.1E5;NRDGS 8;TRIG SGL"
2750 OUTPUT 722;"OHMF,1E3;APER 20E-6;DELAY -1; NRDGS 2;TRIG SGL"
2760 OUTPUT 722;"ACV,250;ACBAND 250;DELAY .1; NRDGS 1;TRIG SGL"
2770 OUTPUT 722;"ACV 10;ACBAND 25000;DELAY.01; TRIG SGL"
2780 OUTPUT 722;"DCV,10;NPLC 0;DELAY 0;NRDGS 6;TRIG SGL"
2790 OUTPUT 722;"ACV,10;ACBAND 5000;APER 20E-6;DELAY .01;NRDGS 1;TRIG
    SGL"
2800 OUTPUT 722;"DCV10;NPLC 0;DELAY 0;NRDGS 3;TRIG SGL;SUBEND"
2810 Dnld_time=TIMEDATE-Dnld_time
2820 Exe_time=TIMEDATE
2830 OUTPUT 722;"CALL 1"
2840 Exe_time=TIMEDATE-Exe_time
2850 Tns_time=TIMEDATE
2860 FOR I=1 TO 37
2870 ENTER 722;A(I)
2880 NEXT I
2890 Tns_time=TIMEDATE-Tns_time
2900 SUBEND

10 !MAIN PROGRAM
20 COM A(20),B(90),C(30),D(30),J$[80]
30 CALL Test_58(Time58)
40 END
50 !
60 !
70 SUB Test_58(Time58)
80 DIM A(20),B(90),C(30),D(30),J$[80]
90 !SET UP SCANNER
100 ASSIGN @Scan TO 709

```

```

110 ASSIGN @Dmm TO 722
120 CLEAR @Dmm
130 OUTPUT @Dmm;"RESET" !Sets the dmm to power-up state
140 OUTPUT @Dmm;"TRIG HOLD" ! Stops triggering
150 !
160 ! ----- ScannerSetup -----
170 !
180 OUTPUT @Scan;"RESET"
190 OUTPUT @Scan;"CLOSE 200,400,410;STORE 1"
200 OUTPUT @Scan;"CLOSE 308,309;STORE 2"
210 OUTPUT @Scan;"OPEN 200"
220 OUTPUT @Scan;"CLOSE 201; STORE 3"
230 OUTPUT @Scan;"OPEN 201"
240 OUTPUT @Scan;"CLOSE 206;STORE 4"
250 OUTPUT @Scan;"OPEN 206"
260 OUTPUT @Scan;"CLOSE 202;STORE 5"
270 OUTPUT @Scan;"OPEN 202"
280 OUTPUT @Scan;"CLOSE 205;STORE 6"
290 OUTPUT @Scan;"OPEN 205"
300 OUTPUT @Scan;"CLOSE 204;STORE 7"
310 OUTPUT @Scan;"OPEN 204"
320 OUTPUT @Scan;"CLOSE 203;STORE 8"
330 !
340 ! ----- Channel list -----
350 !
360 OUTPUT @Scan;"SLIST 1,2,3,3,4,4,5,5,6,6,7,8.8,0"
370 !     Setup the scan list for the states
380 !     that are automatically incremented
390 !     by the STEP command or the external
400 !     increment input signal

```

```

410 OUTPUT @Scan;"DMODE 1,1,0,1"! Setup for external increment
420 !    and channel close on the scanner.
430 !
440 ! ----- Measurement Setup -----
450 !
460 OUTPUT @Dmm;"PRESET;TARM HOLD"!Sets the dmm in its normal PRESET
461 !    and holds the trigger arm
462 OUTPUT @Dmm;"MFORMAT DREAL"! Stores the data in memory in IEEE
463 !    double-real format
470 OUTPUT @Dmm;"TRIG EXT"!Sets the dmm to trigger externally
480 OUTPUT @Dmm;"APER 20E-6"!Sets the integrator aperture to 20 µs
490 OUTPUT @Dmm;"TBUFF ON"! Sets-up the trigger buffer
500 !    does not occur
510 OUTPUT @Dmm;"DISP OFF !    Turns off the front panel display on
the dmm
520 OUTPUT @DMM;"DELAY 0"!    Sets the time between trigger event
530 !    and measurement start to 0 s
540 !
550 ! ----- Measurement List -----
560 !
570 OUTPUT @Dmm;"SUB 1"! Start of the dmm program
580 OUTPUT @Dmm;"MEM FIFO"! Sets memory to first-in, first-out
590 OUTPUT @Dmm;"DCV 10" !    Sets the dmm to dcV function and 10 volts
max
600 OUTPUT @Dmm;"TARM SGL"! (1) Initiates the measurement sequence once
the
610 ! TRIG EXT is satisfied and stops after just
620 ! one trigger event occurs.
630 OUTPUT @Dmm;"TARM SGL"!(2) Repeats the sequence again.
640 OUTPUT @Dmm;"TARM SGL"!(3) And again

```

```

650 OUTPUT @Dmm;"ACBAND 1000" ! Sets the lower frequency range to 1
    kHz
660 OUTPUT @Dmm;"ACV 10"!Sets the dmm to 10 volts maximum input in acV
670 OUTPUT @Dmm;"TARM SGL"! (3
680 OUTPUT @Dmm;"TARM SGL"! (4)
690 OUTPUT @Dmm:"DCV 10"
700 OUTPUT @Dmm;"TARM SGL"! (4)
710 OUTPUT @Dmm;"TARM SGL"! (5)
720 OUTPUT @Dmm;"ACV 10"
730 OUTPUT @Dmm;"TARM SGL"! (5)
740 OUTPUT @Dmm;"TARM SGL"! (6)
750 OUTPUT @Dmm;"DCV 10"
760 OUTPUT @Dmm;"TARM SGL"! (6)
770 OUTPUT @Dmm;"TARM SGL"! (7)
780 OUTPUT @Dmm;"OHM 3E3"!Sets the dmm to  $\Omega$  function and 3 k $\Omega$ 
790 OUTPUT @Dmm;"TARM SGL"! (8)
800 OUTPUT @Dmm;"OCOMP ON"! Turns on offset compensation.
810 OUTPUT @Dmm;"TARM SGL"! (8)
820 OUTPUT @Dmm;"SUBEND" !End of dmm program memory
830 !
840 ! ----- Measurement Execution -----
850 !
860 OUTPUT @Dmm USING "#,K";"CALL 1;"! Calls the dmm program
870 OUTPUT @Scan;"STEP"!Moves to the first setup and triggers the dmm
880 !
890 !--Transfer readings from dmm to computer--
900 !
910 FOR I=1 TO 13
920 ENTER @Dmm;A(I)
930 PRINT USING "SD.DDDE";A(I)

```

940 NEXT I

950 SUBEND

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E High Resolution Digitizing With the 3458A

Introduction	478
Speed with Resolution	479
Choice of Two Measurement Paths	482
Capturing the Data	485
High Speed Data Transfers	489
Errors in Measurements	494

(From Product Note 3458A-2)

Introduction

In your system or stand-alone with your computer, the 3458A can digitize wave forms with low distortion and very high resolution. The 3458A has the measurement speed and precise timing necessary for direct sampling of signals with frequency components up to 50 kHz or, with repetitive signals, subsampling up to 12 MHz with 16 bits of resolution and more.

In this product note you will learn how to:

- 1** Configure the 3458A to capture transient signals using direct sampling.
- 2** Configure the 3458A to capture repetitive signals using sequential sampling.
- 3** Use slope and level triggering to capture the data where you want.
- 4** Transfer measured signal data from the 3458A to your HP 9000 Series 200/300 Computer at 100 kSamples/s.
- 5** Use the 3458A's Program Memory to capture signals on multiple channels, store them in the 3458A's Reading Memory, interrupt the HP 9000 Series 200/300 Computer when the task is complete, and transfer the data from the multimeter to the computer for comparison, analysis, and graphic presentation.
- 6** Use the 3458A Option 005 Wave Form Analysis Library, to acquire, analyze, and present the digitized signals.
- 7** Interpret specifications that pertain to wave form digitizing and dynamic performance.

Speed with Resolution

- 16 bits @ 100 kSamples/s
- 18 bits @ 50 kSamples/s

The 3458A offers you complete flexibility for speed and resolution over the audio frequency bandwidth. The DCV measurement path can digitize your audio frequency signal with less than 175 ns trigger latency and less than 100 ps measurement-to-measurement jitter. Through the track-and-hold path, the 3458A can digitize repetitive signals up to 12 MHz at 50 kSamples/s with 16 bits resolution by using sequential sampling (subsampling).

Digitizing analog signals

Most digital signal processing systems may be represented as illustrated in [Figure E-1](#).

In any digital processing system, there is a minimum allowable sampling rate called the Nyquist Rate and it is specified by the Sampling Theorem, summarized as follows:

- When digitizing an analog signal, the sampling rate must be at least twice as great as the highest frequency component (f_0) in the spectrum of the sampled signal. Frequency components higher than f_0 will “alias” down into the frequency range below f_0 and interfere with the accurate representation of the sampled signal. For example, since a square wave can be represented as an infinite sum of sinusoids (Fourier Series) and contains very high frequency components, attempting to digitize this signal without an anti-aliasing filter on the input will severely alias the captured signal so that representations of the actual signal may be meaningless.

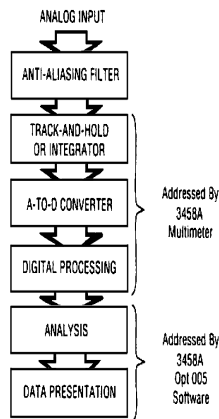


Figure E-1 In general, digital signal processing systems require a close look at various functions beginning with the analog signal and ending with results meaningful to the user.

Avoiding aliasing

To avoid signal distortion caused by aliasing, the effective sample interval must meet the Nyquist criterion of $1/(2f_0)$. In direct sampling, the effective sample interval is the actual time between measurements selected. Therefore, through the track-and-hold path or through the DCV path (explained in the next section), the maximum signal frequency is 25 kHz or 50 kHz for 20 μ s or 10 μ s sample intervals, respectively. If higher frequencies are present, then a low-pass filter of bandwidth f_0 or less should be inserted in the signal path.

For sequential sampling, the effective sample interval is the time between samples of the reconstructed wave form (refer to [Figure E-2](#)). If you select an effective sampling interval of less than 35 ns, the bandwidth of the track-and-hold path, 12 MHz, eliminates most distortion caused by aliasing. If the effective sample interval is greater than 35 ns and frequencies higher than 12 MHz are present, an external filter is necessary as well.

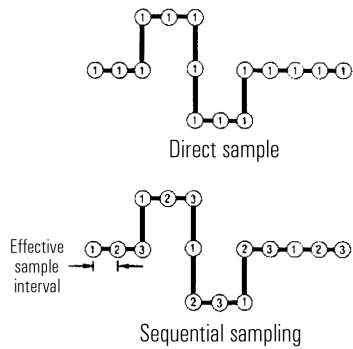


Figure E-2 Direct sampling acquires the wave form in one pass of the input. Sequential sampling requires a repetitive signal where the period is reconstructed in several passes. The numbers shown represent samples acquired in one period of the input.

Choice of Two Measurement Paths

The 3458A provides two different input measurement paths: the standard DCV path and the track-and-hold path (see [Figure E-3](#)). The track-and hold path is used for subsampling and direct sampling. The DCV path is used for direct sampling alone. At your discretion, you may use the standard DCV path for subsampling, but you have to program the algorithm for data capture.

Using the DCV path for direct sampling

The standard DCV path is selected for you when you program the command “PRESET DIG”. This command establishes default parameters to directly digitize the input signal, assuming that you will want 256 samples at 50 kSamples/s with full scale set at 10 V peak. The trigger circuit assumes that you want to trigger on the input signal at 0 V level, positive slope, AC coupled. Hence, with these default conditions you can capture at least one cycle from 200 Hz up to 25 kHz.

The standard DCV path also offers speed and resolution tradeoffs from 18 bits (5 1/2 digits) at 6 kSamples/s to 16 bits (4 1/2 digits) at 100 kSamples/s. The noise floor on the 10 V range for the corresponding sample rates are 0.005%, and 0.05%, respectively.

As the resolution is increased in the DCV path there is a corresponding increase in the aperture time. Hence, the obvious trade-off for lower noise and more resolution is the loss of information because of the broadening of the sample aperture. To capture the peak value of a pulse, the aperture must be no wider than the pulse width. From a practical viewpoint, trigger uncertainty can make the task of capturing peak amplitudes nearly impossible for pulses near the width of the sampling aperture. The solution is to narrow the aperture to a point where the bandwidth of the input amplifier is the resolution limiting factor, not the sample aperture.

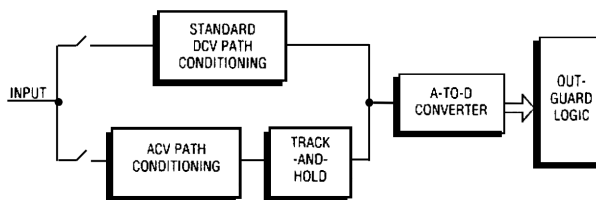


Figure E-3 The 3458A multimeter provides two different digitizing paths, the standard DCV path and a track-and-hold path.

Using the track-and-hold path for direct or sequential sampling

The track-and-hold path is the solution to capturing the amplitude of narrow pulses. This path has a bandwidth of 12 MHz and a fixed aperture of 2 ns. With trigger jitter of 2 ns, you can, with a little searching, capture the peak amplitude of a pulse as narrow as 40 ns without measurement degradation, as indicated in [Figure E-4](#). Rise times of less than 10 ns will cause overshoot in a digitized measurement; hence, if it is likely that signals with these frequency components will be applied to the input of the 3458A, then bandlimit the signal by filtering. Direct digitizing with the track-and-hold path allows the capture of signals with frequency components up to 12 MHz. The same path is used to subsample repetitive signals up to 12 MHz.

Programming the 3458A for direct or subsampled (sequential) digitizing using the track-and-hold path is simple. Only one command is required. For example, DSAC provides direct sampling, AC coupled, or SSAC provides sequential sampling, AC coupled. These commands automatically use default parameters that can be changed.

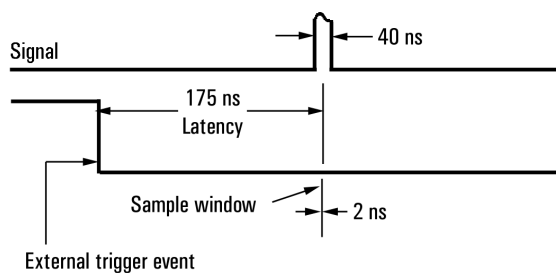


Figure E-4 Capturing the pulse amplitude of narrow pulses requires the use of the 12 MHz track-and-hold path. Note, the minimum time between sample acquisition and trigger event is 175 nanoseconds.

Capturing the Data

The 3458A can be triggered to commence the measurement cycle by the level and slope of the input signal, by a zero voltage level crossing of the power line, by the GET (group execute trigger) command on the GPIB, by an external TTL signal, by an internally generated trigger signal (for burst measurements, this can be paced), and by the computer asking for a reading.

The 3458A provides all the tools you need to catch the signal of interest by offering three levels of triggering and up to eight conditions to satisfy including the wave form's level and slope. The hierarchy of trigger levels is trigger arming (TARM), trigger (TRIG), and number of readings per trigger (NRDGS). Focused at digitizing, two additional commands are used for direct sampling and subsampling: SWEEP which is related to NRDGS, and SSRC which selects the trigger source (level or external) for subsampling. You can choose from a variety of events or conditions that must be satisfied before taking measurements, as shown in [Figure E-5](#). The default condition for all three levels of triggering is AUTO; the 3458A will generate its own trigger as fast as the multimeter set-up allows.

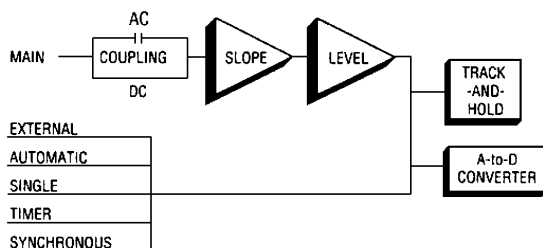


Figure E-5 The trigger event choices shown provide the versatility needed to match a wide variety of applications.

TARM is the first condition to be satisfied. Its function is to arm the trigger circuit prior to receiving the trigger signal. For example, if a synchronizing signal were available external to the signal of interest, then TARM EXT could be used to arm the 3458A to look for the trigger event. Also, TARM can be used to control multiple measurement sequences by adding the number of times you want a particular measurement cycle repeated. For example, TARM SGL,4, specifies that the trigger arming be applied four times and then stops. Refer to [Figure E-6](#).

```

10 OUTPUT 722; "TARM HOLD" ! Places the 3458A in a measurement hold
condition.
20 OUTPUT 722,"TRIG EXT" ! Sets the trigger event to trigger.
30 OUTPUT 722, "NRDGS 5, TIMER" ! Sets up a burst of five readings for
every trigger.
40 OUTPUT 722; "TIMER 2E-3" ! The time between readings will correspond
to the TIMER setting(2E-3 or 2 ms)
...
200 OUTPUT 722; "TARM SLG, 4" ! Four burst of measurements are allowed
to begin when the external triggers occur

```

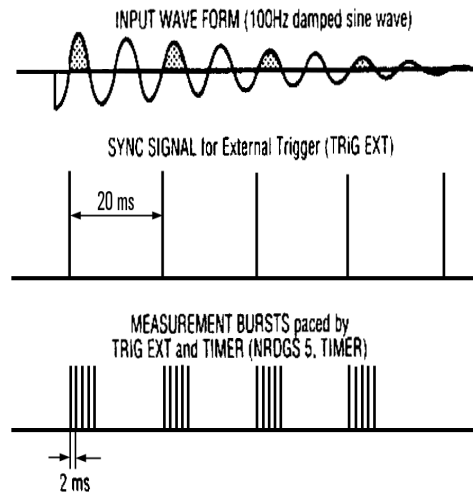


Figure E-6 Digitizing with the standard triggering command. Trigger Arming, TARM SGL, 4 allows a measurement cycle to occur only 4 times, reducing the amount of data necessary to determine the ratio of the shaded areas in the input wave form.

TRIG is the next condition to be satisfied. Only after both TARM and TRIG event conditions are satisfied can a burst measurement be made with NRDGS. Refer to [Figure E-7](#).

```
NRDGS [# of readings] [,event]
```

lets you specify the number of readings to take, the trigger condition for each reading, and the number of readings saved in memory before or after the trigger event.

The SWEEP and SSRC commands are specifically designed to make the task of digitizing easier. The

SWEEP [effective interval between readings] [, number of readings]

command combines the NRDGS parameters with TIMER. SSRC selects the synchronizing source for subsampling, either external or level. Both the SWEEP and SSRC commands are used for SSAC (subsampled, AC coupled) and SSDC (subsampled, DC coupled), and the NRDGS and TRIG are ignored. For DSAC (direct sampled, AC coupled) and DSDC (direct sampled, DC coupled) all triggering commands are valid but the use of both in the same measurement is not recommended.

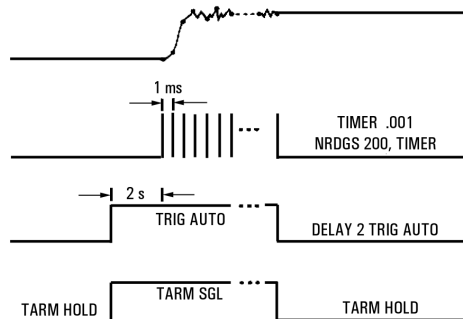


Figure E-7 Once the trigger arming and trigger event conditions are satisfied, a burst of measurements can digitize a wave form as shown in this example.

The SSRC command offers you either internal level triggering or synchronization with the external trigger. In the subsampling mode, the SSRC EXT calculates the number of external triggers it needs to accomplish the measurement you specify with the SWEEP command.

For example, if you want to capture a wave form with 100 ns time resolution for 4096 readings

[SWEEP 100E-9,4096]

the 3458A multiplies the number of readings by the time interval and divides by the minimum time between samples.

Delay can be used in conjunction with external trigger synchronization to window your measurement to examine the parts of the wave form you want to see in detail. For example, consider using the 3458A as a broadband phase/gain meter with a 3325A source to measure the transfer function of a passband filter over a frequency range of 0.5 to 5 MHz. Refer to [Figure E-8](#). The highest frequency is 5 MHz so the minimum time between samples for entire band is 100 ns for two samples per cycle. Two methods suggest themselves for this analysis: (1) sweep the entire frequency spectrum at 100 ns interval or (2) divide the frequency spectrum into bands and sweep these bands at the $1/(2f_0)$ for the band. In the first case, the data acquisition time is minimized, in the second case the need for a fast computer is minimized.

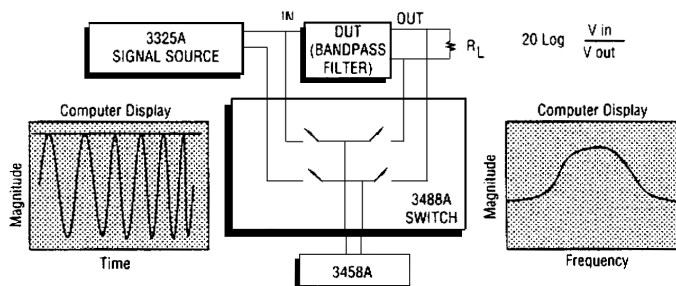


Figure E-8 Using the 3458A as a phase/gain meter with a swept frequency generator for magnitude only Bode plots. The DUT can be characterized over frequency with a phase synchronous trigger to time the measurement.

High Speed Data Transfers

The 3458A can transfer readings at its maximum reading rate to a 9000 Series 200/300 computer with a direct memory access card only the computer is set up to capture the data at this rate. The readings can be taken from the 3458A internal memory or as the dmm is making the measurements. Two conditions must occur: the dmm has to be devoted to high speed readings and the proper buffers must be set up in the computer.

PRESET DIG is exactly the command needed for the 3458A. It sets up the DMM for the highest speed possible.

As long as direct digitizing is the desired operation, there is no problem in reconstructing the wave form as it is presented to the computer. If you use the memory for data storage before transferring the captured signal, the 3458A orders the data for you.

Software help the wave form analysis library

The Wave Form Analysis Library, 3458A Option 005 (03458- 80005), not only lets you acquire the wave form without having to use even the simple commands to control the 3458A, but it also lets you analyze and present the data with a minimum of computer and instrument knowledge. A simple sequence of measurement setup, measurement acquisition, analysis, and presentation is all that you have to keep in mind while developing your master program that calls up both BASIC language and compiled subprograms. Refer to [Figure E-9](#).

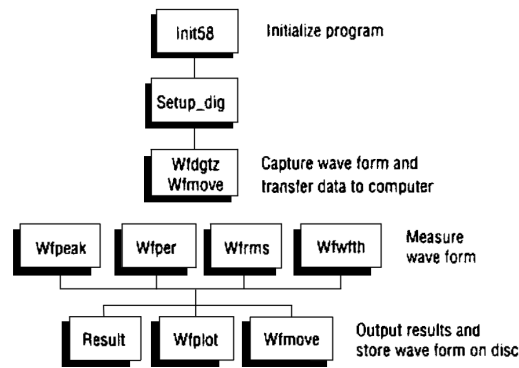


Figure E-9 Here is a typical way to structure your own automatic measurement program using the Library Subprograms (not necessarily a complete list).

In addition to time domain analysis like frequency, risetime, pulse width, and overshoot, the Wave Form Analysis Library offers frequency domain analysis with Fast Fourier Transform (FFT) and Inverse Fourier Transform (IFT), with the Hanning filter function. Further, the Wave Form Analysis Library gives you a “Fast Scope” program that lets your 3458A and a HP 9000 Series 200/300 computer take measurements up to 50,000 Samples/s and present the data to the computer display at a refresh rate up to 5/s. In effect, the combination gives you a very high resolution single channel oscilloscope of 12 MHz bandwidth.

The Wave Form Analysis Library also lets you compare a previously captured wave form with limits on the measurements to the input signal.

Several utility functions are also provided with the Wave Form Analysis Library: **Format**, which formats the output display in engineering units, **Intrpo**, which performs a linear interpolation between sample points, **Sinc**, which performs a sinc function interpolation between sample points for signals captured near the Nyquist limit, and **Warn58**, which prints error and warning messages on the computer CRT or printer.

As an example, consider how the Wave Form Analysis Library can be used to capture an AM modulated signal to extract the carrier, the modulation frequency, and the depth of modulation.

First, the main program must be written to call the library subprograms. The main program is a block of program code that controls and invokes the subprograms in the order necessary to solve the measurement problem. The main program can be short or long depending on the needs of the measurement task. Part of a main program is shown in below. This program captures a wave form using the 3458A, transfers the wave form to the computer, and plots the wave form on the computer's CRT. It uses four Library subprograms: Setup_dig, the dmm setup subprogram that determines the way you are going to digitize the wave form (DCV, DSAC, DSDC, SSAC, SSDC), the time interval between samples, and the number of samples (if you plan on using the FFT or IFT routines, the number of samples must be a power of two); Wfdgtz, the wave form capture subprogram; Wfmove, the transfer subprogram; and Wfplot, the plotting subprogram.

```
1280 CALL Setup_dig(1,1.e-5,1000)
1270 CALL Wfdgtz(1)
1280 CALL Wfmove("1","98",Scal(*),Wavf(*),Clip)
1290 CALL Wfplot(Scal(*),"Wave form 1",Wavf(*),1,1)
```

The subprogram is one of the most powerful elements available in any programming language. Each subprogram has its own context or state as distinct from the main program. This means that every subprogram has its own set of variables and its own line labels.

Starter main program

Every program using the library subprogram requires a main program. Many of the data arrays discussed in this part must be dimensioned in each main program. Additionally, the COM statements used by many of the library subprograms are needed in most main programs. Included with the Wave form Analysis Library is a starter main program that can form the beginning of all main programs as shown here.

```
10 ! Main
20 ! Core main program programming aid
30 !*** COMMON
40 COM/Hp3458/@Recorder,Xist_plotter,Prt,Bus,Xist
50 !*** Real Arrays
60 REAL Scal(0:4),Yamp(0:7)
70 !*** STRINGS
80 DIM Source$(50),Destin$(50),Titles$(30)
90 !*** INTEGER ARRAYS
100 INTEGERWavf(1:16384),Redg(0:30),Fedg(0:30),Bandwf(0:163)
```

```

110 DISP                ! Clear display line
120 OUTPUT I USING "@" ! Clear CRT
130 !
140 CALL Init58         ! Wake up the bus
150 !
160 GINIT               ! Initialize graphics
170 !
180 ! Insert user main program here
250 ! to here
260 END

```

Returning to the original problem, the subprograms needed to analyze the AM modulated signal are:

Setup_dig, Wfdgtz, Wfmove, Fft, and Fft_plot.

In other words the following would be inserted as the main program:

```

190 CALL Setup_dig(2,20E-6,512)
200 CALL Wfdgtz (1)
210 CALL Wfmove("1", "98", Scal(*),Wavf(*),Clip)
220 CALL Fft
    (512,1,Hanning,Wavf(*),Real_dat(*),Imag_dat(*),Magn_dat(*))
240 CALL
    Fft_plot(Magn_data(*),Smpl_intvl,Dyn_range,F_start,F_stop,Title$)
250 END

```

The results of this program are shown in [Figure E-10](#).

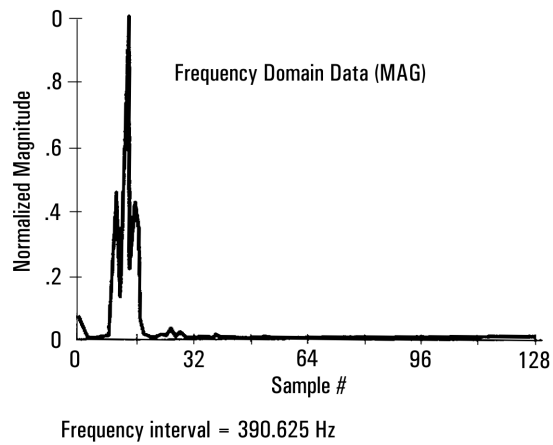


Figure E-10 Example of results generated using the Wave Form Analysis Library.

Errors in Measurements

The flexibility of the 3458A helps you avoid or compensate for many of the measurement errors that can occur in the digitizing process. Errors associated with digitizing can be grouped by their amplitude error and time error contributions to the total error in the measurement. For dynamic signals, time errors result in amplitude error. Fortunately, most time dependent measurements are differential and any absolute timing errors are calibrated out of the measurement. A close look at the block diagram of the 3458A reveals the sources of error in the measurement, summarized in [Figure E-11](#).

Broadly speaking, errors that creep into digitizing measurements are evident in both the amplitude and time axes.

For amplitude, the errors are:

- 1** Quantization error
- 2** Missing code
- 3** Non-linearity
- 4** Noise
- 5** Bandwidth
- 6** Amplitude accuracy

On the time axes, the error factors are:

- 1** Timebase reference jitter
- 2** Trigger uncertainty
- 3** Trigger accuracy
- 4** Trigger latency
- 5** Aperture width
- 6** Aperture jitter

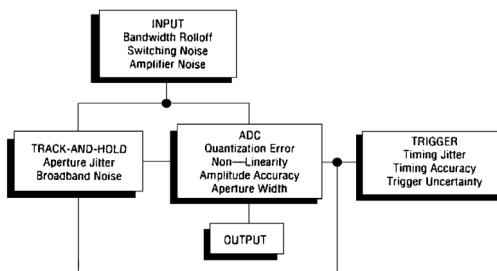


Figure E-11 These digitizing error sources should be considered in any measurement.

Amplitude errors

The input signal conditioning section of the 3458A has switches (relays), attenuators, and amplifiers associated with conditioning and routing the signal for either the Analog-to-Digital (ADC) or the track-and-hold. Auto zero eliminates input offset errors but the residual error does propagate. This section is the low frequency section of the 3458A. Hence, depending on the range, the signal is routed through a low pass filter (the input amplifier) before being presented to the ADC.

Quantization error is the fundamental, irreducible error associated with the perfect quantizing of a continuous (analog) signal into a finite number of digital bits. Hence, the resolution of the ADC has a direct impact on your ability to measure the input wave form in detail. Some limitations may be overcome by window amplifiers that will allow the signal's detailed examination in the presence of large offsets, but the introduction of the amplifier adds error to the measurement that is not necessary for high resolution ADCs.

Missing code may only manifest itself at high speed. The most common cause of missing code is dielectric absorption (DA), the polarization of dipoles in the insulating material surrounding the conductor. Careful design can eliminate this problem, but DA can cause measurements to have a “memory” of previous measurements. If sufficient settling time is given to the ADC, the problem falls below the quantization level.

Missing code coupled with quantization error results non-linearity of the ADC. This occurs in two forms: differential and integral non-linearity. Differential nonlinearity is the largest step that occurs between successive quantization

levels. Integral non-linearity is the maximum deviation of the linearity curve from a least-mean-square fit. In general, differential non-linearity may cause significant measurement error if a low level signal happens to fall on that part of the ADC transfer function with the differential non-linearity error. Integral non-linearity in an ADC is generally more detrimental when digitizing full scale signals.

Realize that the transfer function for an ADC is very dependent upon the slew rate (dV/dt). The transfer function for a static DC input level may appear close to the ideal. The transfer function under dynamic operating conditions may exhibit numerous errors as shown in [Figure E-12](#).

An inescapable reality in any measurement is the attendant noise with increasing bandwidth. The effects of random measurement noise can be reduced by averaging the measurements. Caused by Johnson noise and other circuit related noise as well as noise on the input signal, the removal of this noise always costs measurement time. A measure of the quality of a digitizing instrument, called the “effective bits” of resolution, combines noise with ADC linearity to show the usable resolution of the digitizer:

$$\text{effective bits} = N - \log_2(\text{rms error (actual)} / \text{rms error (ideal)})$$

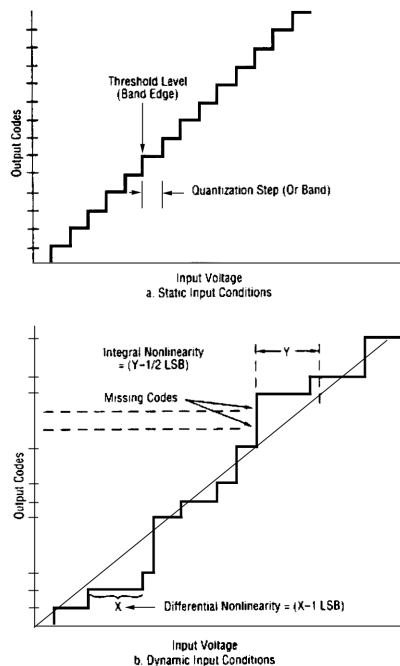


Figure E-12 With static DC input levels, the analog-to-digital converter may exhibit an ideal transfer function as shown in 12a. With a dynamic input, however, errors shown in 12b may appear.

The rms error (actual) is the error measured relative to the best-fit perfect sine wave. The rms error (ideal) is the theoretical error from a perfect N bit ADC. For low resolution instruments, the effective bits is a true measure quality; for high resolution instruments, the noise associated with any measurement swamps the actual performance of the ADC. If, however, a large number of samples is taken or, equivalently, the samples are averaged, the noise can be reduced to the point where actual quantization and non-linearity errors are evident in the Fourier transform of the sampled data. This effect is shown in [Figure E-13](#). The third harmonic of the input signal is actually an integral non-linearity. Averaging ten samples does not remove its level, whereas the noise floor drops 10 dB.

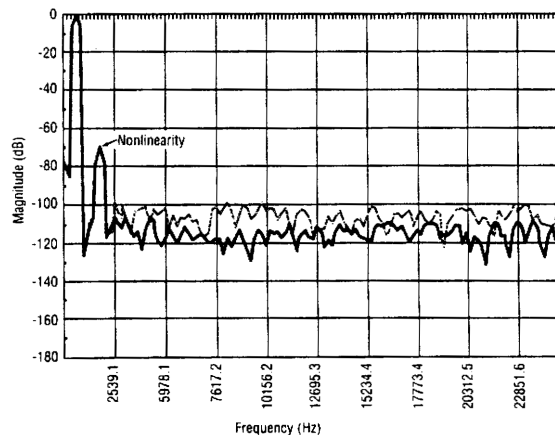


Figure E-13 Analog-to-digital converters that exhibit non-linearity errors cause spurious responses that averaging will not remove. The 3458A is linear to 16 bits at 100,000 readings/s.

The 3458A offers two input paths. The differences are that the direct ADC path (DCV) offers up to 160 kHz bandwidth up to a sampling rate of 100,000 samples per second; the track-and-hold path offers 12 MHz bandwidth at a sampling rate of 50,000 readings per second. Both paths exhibit single pole roll-off; both are nominally three dB down (half power) at the bandwidth point. Hence, two errors can creep into your measurements: aliasing and amplitude roll-off. In the track-and-hold path aliasing can be eliminated by increasing the effective sampling rate up to 100 MSamples/s and the track-and-hold circuit can be characterized for amplitude roll-off over the band of interest to compensate for the roll-off. In the case of the DCV path, the only real solution to aliasing is to supply a low pass analog filter. See [Figure E-14](#).

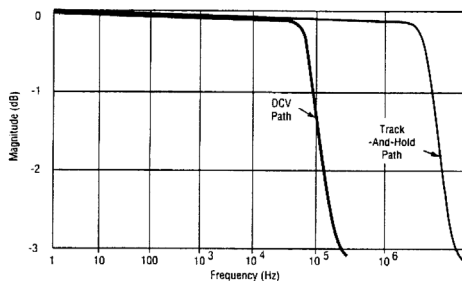


Figure E-14 Amplitude roll-off of the 3458A multimeter for its two different measurement paths.

Finally, the accuracy of the measurement itself, although not often discussed with digitizers, is related to the reference accuracy of the 3458A. For static and dynamic measurements, the absolute accuracy actually exceeds the dmm's resolution. And, in terms of long term drift, the absolute error is less than 7 ppm per year.

Trigger and timebase errors

The timebase, a precision temperature compensated quartz crystal, has its drift and jitter which will affect the amplitude measurement of the input signal. But, these tend to be very small - less than 50 ps. Hence, the clock accuracy and jitter do not really affect the measurement within the measurement bandwidth of the 3458A. The timebase jitter error is not cumulative; therefore each sample point has only its own jitter error and not the combined jitters of previous sample points. The effects of all the time axis errors are shown in [Figure E-15](#).

The trigger error is orders of magnitude greater than timebase error and jitter. Two effects cause this. The 3458A has no delay line, so there is a trigger latency, a time delay between the trigger and the commencement of the measurement, that is fixed by the firmware, the clock, and the timing circuits. It is specified to be less than 175 ns for an external trigger. The accuracy of the trigger can also be affected by noise on the trigger signal and time interpolator variation between measurements. This is of the order of 50 ps as well except in very noisy cases, where it is advisable to use the 3458A's trigger filter which reduces the bandwidth of the trigger circuit to a nominal value of 70 kHz.

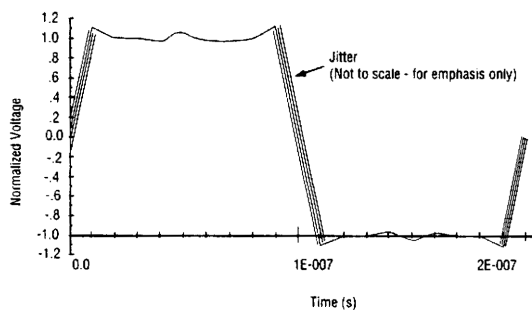


Figure E-15 The effects of timebase jitter is shown here. For the 3458A multimeter, the jitter is 50 ps RMS. This jitter is repeatable so it can be characterized and corrected.

Index

A

A/D converter, configuring the, 91

AC

- bandwidth, 160
- current, 101
- measurements, configuring for, 98
- voltage, 98
- voltage method, specifying the, 100

AC+DC

- current, 101
- voltage, 98

ACAL, 234

ACBAND, 235

Accessories, options and, 32

ACDCI, 237

ACDCI example, fast, 162

ACDCI key, 51

ACDCV, 237

ACDCV example

- fast analog, 162
- fast synchronous, 161

ACDCV key, 51

ACI, 237

ACI example, fast, 162

ACI key, 51

ACV, 237

ACV example

- fast analog, 162
- fast synchronous, 161

ACV key, 51

ADDRESS, 237

Address

- changing the GPIB, 71
- key, 70
- reading the GPIB, 70

Analog

- ACDCV example, fast, 162
- ACV example, fast, 162
- RMS conversion, 100

Annunciator

- AZERO OFF, 48
- ERR, 48
- LSTN, 48
- MATH, 48
- MORE INFO, 48
- MRNG, 48
- REM, 48
- SHIFT, 48
- SMPL, 48
- SRQ, 48
- TALK, 48
- APER, 238
- Aperture waveform, 172
- Applying power, 46
- ARANGE, 239
- Arming, multiple trigger, 129
- ASCII, 140
- Auto key, 53
- Autocal

 - running, 77
 - when to use, 78

- Autocalibration, 77
- Autorange, 84
- Autoranging and manual ranging, 52
- Autostart subprogram, 114
- Autozero, 95
- AUXERR?, 240
- AZERO, 242
- AZERO OFF annunciator, 48

B

Back Space key, 64

Bandwidth

- AC, 160
- specifying, 103

BASIC language, 39

BEEP, 243

Before applying power, 45

Binary coding, two's complement, 141

Buffering, external trigger, 135

Burst complete, 171

Bus, sending readings across the, 149

C

Cable

- lengths, GPIB, 38
- power, 34

Cable, connecting the GPIB, 38

CAL, 244

Calibration, 76

CALL, 244

CALNUM?, 245

CALSTR, 246

Caps

- line fuse, 40
- switch lockout, 419

Changing

- GPIB address, 71
- measurement function, 51

Choices, event, 126

Clear key, 55, 64

Clearing the display, 64

Coding, two's complement binary, 141

Combinations, event, 136

Command

- sending a remote, 71
- termination, 226

Command, PRESET FAST, 158

Commands

- functional group, 230
- multiple, 227
- query, 62, 228
- standard query, 228

Compensation, offset, 96, 160

COMPRESS, 247

Compressing subprograms, 114

Computers, series 200/300, 39

Configuration, general, 75

Configuration, using the keys, 57

Configuring

- A/D converter, 91

- for AC measurements, 98
- for DC or resistance measurements, 86
- for fast readings, 157
- for ratio measurements, 109
- Connecting the GPIB cable, 38
- CONT, 248
- Continuous readings, 127
- Controller, sending samples to the, 215
- Conventions, language, 226
- Conversion
 - analog RMS, 100
 - synchronous sampling, 99
- Cords, power, 37
- CSB, 248
- Current
 - AC, 101
 - AC + DC, 101
- Cycles, specifying power line, 92

D

- DB, 181
- DBM, 182
- DC current, 87
- DC or resistance measurements, configuring for, 86
- DC voltage, 86
- DCI, 249
 - example, high-speed, 161
- DCV, 249
 - digitizing, 201
 - example, 203
 - example, high-speed, 160
- DCV key, 51
- DCV remarks, 202
- Def Key, 67
- Default
 - delays, 133
 - values, 59
- Defaulting parameters, 227
- DEFEAT, 249
- DEFKEY, 250
- DELAY, 252
- Delay time, 159
- Delayed readings, 133
- Deleting

- states, 117
- subprograms, 115
- DELSUB, 253
- Determining the reading rate, 166
- Devices, GPIB, maximum number of, 38
- DIAGNOST, 254
- Digitizing
 - DCV, 201
 - methods, 193
- Digits displayed, 66
- DINT
 - example, 152
 - output format, using, 151
- Directly, specifying integration time, 93
- Direct-sampling, 205
 - example, 207
 - remarks, 206
- DISP, 254
- Display, 48
 - clearing the, 64
 - control, 64
 - editing, 64
 - MORE INFO, 65
 - test, 55
 - window keys, 65
- Displays, viewing long, 65
- Double integer, 140
- Double real, 142
- DREAL output format, 154
- DSAC, 255
- DSDC, 255

E

- Editing, display, 64
- EMASK, 258
- Enabling math operations, 175
- END, 260
- ENTER statement, 70
- ERR annunciator, 48
- ERR?, 261
- Error
 - register, reading the, 54
 - registers, reading the, 75
- Error key, 54

- ERRSTR?, 263
- Event
 - choices, 126
 - sample, 126
 - sync source, 211
 - trigger, 126
 - trigger arm, 126
- Event combinations, 136
- Example
 - DCV, 203
 - DINT, 152
 - direct-sampling, 207
 - fast ACDCI, 162
 - fast ACI, 162
 - fast analog ACDCV, 162
 - fast analog ACV, 162
 - fast FREQ, 163
 - fast PER, 163
 - fast random ACDCV, 161
 - fast random ACV, 161
 - fast synchronous ACDCV, 161
 - high-speed DCI, 161
 - high-speed DCV, 160
 - high-speed OHM
 - example, 160
 - high-speed OHMF, 160
 - SINT, 151
 - SREAL, 142
- Examples, level triggering, 197
- Executing a subprogram, 112
- Exponential parameters, 60
- External
 - trigger buffering, 135
 - triggering, 134
- EXTOUT, 264
- EXTOUT ONCE, 174
- EXTOUT signal, 168

F

- f0 - f9 keys, 67
- Factory address setting, 39
- Fast
 - ACDCI example, 162
 - ACI example, 162
 - analog ACDCV example, 162
 - analog ACV example, 162

FREQ example, 163
 PER example, 163
 random ACDCV example, 161
 random ACV example, 161
 readings, configuring
 for, 157
 synchronous ACV example, 161
 Ffast ACDCV
 synchronous example, 161
 FILTER, 187
 Filtering, level, 200
 Fixed input resistance, 96
 FIXEDZ, 266
 Format
 using DINT output, 151
 using the DREAL output, 154
 Formats
 memory, 144
 output, 149
 reading, 140
 FREQ, 267
 example, fast, 163
 FREQ key, 51
 Frequency, 102
 Front panel, 49
 FSOURCE, 269
 FUNC, 270
 FUNCTION keys, 51
 Function, changing the
 measurement, 51
 Function, specifying a
 measurement, 83
 Fundamentals, 209
 sub-sampling, 209
 Fuse
 caps, line, 40
 installing the line power, 36
 replacing a current, 40
 replacing the line power, 40
 G
 General configuration, 75
 GPIB
 high-speed transfer
 across, 163
 GPIB address
 changing the, 71
 reading the, 70
 GPIB, devices, maximum number of, 38
 Grounding requirements, 34
 Guarding, 80
 H
 High-speed
 DCI example, 161
 DCV example, 160
 mode, 156
 OHM example, 160
 OHMF example, 160
 transfer across GPIB, 163
 transfer from memory, 165
 Hold, 52
 Hold key, 52
 I
 ID?, 275
 INBUF, 275
 Increasing the reading rate, 156
 Indication, overload, 150
 Initial inspection, 31
 Input
 terminals, selecting the, 78
 Input buffer, 118
 Input complete, 172
 Input/output statements, 70
 Inspection, initial, 31
 Installation verification, 39
 Installing
 keyboard overlay, 68
 line power fuse, 35
 multimeter, 34
 Integer
 double, 140
 single, 140
 Integration time
 and resolution, 159
 directly, specifying, 93
 setting the, 104
 Interrupts, 121
 ISCALE?, 277
 L
 Language
 conventions, 226
 LEVEL, 280
 Level
 filtering, 200
 triggering, 197
 triggering examples, 197
 LFILTER, 282
 LFREQ, 283
 Limits, line voltage, 35
 Line
 fuse caps, 40
 fuses, power, 40
 power fuse, installing the, 36
 power fuse, replacing the, 40
 power requirements, 35
 voltage limits, 35
 voltage switches, setting the, 35
 LINE?, 284
 Local Key, 72
 LOCK, 285
 Long displays, viewing, 65
 LSTN annunciator, 48
 M
 Maintenance, 40
 Manual ranging, 52
 autoranging and, 52
 MATH, 48, 286
 annunciator, 48
 Math operations, 175
 enabling, 175
 Math registers, 177
 Maximum number of, devices, GPIB, 38
 MCOUNT?, 289
 Measurement function
 changing the, 51
 specifying a, 83
 Measurements
 configuring for AC, 98
 configuring for DC or

- resistance, 86
- configuring for ratio, 109
- specifying ratio, 110
- triggering, 125
- Measuring temperature, 189
- MEM, 289
- Memory
 - formats, 144
 - high-speed transfer
 - from, 165
 - using reading, 144
 - using subprogram, 111
- MENU, 61, 291
- menu key, 61
- MENU keys, 61
- Menu scroll, 62
- Methods
 - digitizing, 193
- MFORMAT, 292
- MMATH, 294
- Mode, high-speed, 156
- MORE INFO
 - annunciator, 48
 - display, 65
- MORE INFO annunciator, 48
- Mounting
 - bench-top, 39
 - multimeter, 39
 - rack, 39
- MRNG annunciator, 48
- MSIZE, 298
- Multimeter
 - installing the, 34
 - mounting the, 39
 - presetting the, 81
 - resetting the, 55
- Multiple
 - parameters, 60
 - readings, 129
 - trigger arming, 129
- N
- NDIG, 299
- Nested subprograms, 113
- NPLC, 300
- NRDGS, 303
- Nrdgs/Trig key, 57

- NULL, 178
- Number of, devices, GPIB,
- maximum, 38
- Numeric parameters, 59
- O
- OCOMP, 306
- Offset compensation, 96, 160
- OFORMAT, 307
- OHM, 313
- OHM example, high-speed, 160
- OHM key, 51
- OHMF, 313
- OHMF example,
- high-speed, 161
- OHMF key, 51
- Ohms
 - 2-Wire, 89
 - 4-Wire, 90
- Operating from remote, 70
- OPT?, 313
- Options and accessories, 32
- Output format
 - using DINT, 151
 - using SINT, 151
 - using the DREAL, 154
 - using the SREAL, 153
- OUTPUT statement, 70
- Output termination, 151
- Overlay, installing the
- keyboard, 68
- Overload indication, 146, 150
- P
- Parameter, selecting a, 58
- Parameters, 227
 - defaulting, 227
 - exponential, 60
 - multiple, 60
 - numeric, 59
- Pass/fail, 185
- PAUSE, 314
- PER, 316
 - example, fast, 163
- PER key, 51
- Percent, 180

- Period, 102
- Power
 - applying, 46
 - cable, 34
 - consumption, 35
 - cords, 37
 - fuse, installing the line, 36
 - fuse, replacing the line, 40
 - line cycles, specifying, 92
 - line fuses, 40
 - requirements line, 35
 - switch, 46
- Power-on
 - self-test, 46
 - state, 46
- PRESET, 318
- PRESET FAST command, 158
- Presetting the multimeter, 81
- PURGE, 320
- Q
- QFORMAT, 321
- Queries, standard, 62
- Query commands, 62, 228
 - standard, 228
- R
- R, 323
- Rack mount, 39
- Random
 - ACDCV example, fast, 161
 - ACV example, fast, 161
 - sampling conversion, 100
- RANGE, 323
- Ranging
 - autoranging and manual, 52
 - manual, 52
- RATIO, 327
- Ratio measurements, 109
- Read, using implied, 148
- Reading
 - error register, 54
 - error registers, 75
 - formats, 140
 - GPIB address, 70
 - memory, using, 144

- numbers, using, 146
- rate, determining, 166
- rate, increasing the, 156
- status register, 120
- Reading complete, 170
- Readings
 - across the bus, 149
 - configuring for fast, 157
 - continuous, 127
 - delayed, 133
 - multiple, 129
 - recalling, 146
 - single, 128
 - suspending, 81
 - synchronous, 130
 - timed, 131
- Recall, 66
 - state key, 57
- Recalling
 - readings, 146
 - states, 117
- Reference frequency, 91, 92
- Register
 - reading the error, 54
 - reading the status, 120
- Registers
 - math, 177
 - reading the error, 75
- REM annunciator, 48
- Remarks
 - DCV, 202
 - direct-sampling, 206
 - sub-sampling, 212
 - synchronous sampling, 99
- Remote
 - command, sending a, 71
 - operating from, 70
- Repair service, 41
- Repairs, warranty, 41
- Replacing
 - current fuse, 40
 - line power fuse, 40
- Requirements
 - grounding, 34
 - line power, 35
- RES, 328
- RESET, 331
- Reset key, 55

- Resetting the multimeter, 55
- Resistance, 89
 - fixed input, 96
- Resolution
 - integration time and, 159
 - specifying, 94, 106
 - when to specify, 107
- REV?, 333
- RMATH, 333
- RMEM, 335
- RMS
 - conversion, analog, 100
- RQS, 337
- RSTATE, 338
- Running autocal, 77

S

- Samples
 - to memory, 214
 - to the controller, 215
- Sampling
 - rate, 195
 - remarks, synchronous, 99
- Sampling conversion
 - random, 100
 - synchronous, 99
- SCAL, 339
- SCALE, 179
- SCRATCH, 339
- Scroll keys, menu, 62
- SECURE, 339
- Selecting
 - input terminals, 78
 - parameter, 58
- Self-test, 53, 75
 - power-on, 46
- Sending
 - readings across the bus, 149
 - remote command, 71
 - samples to memory, 214
 - samples to the controller, 215
- Serial number, 41
- Series 200/300 computers, 39
- Service
 - repair, 41
 - request, 173

- SETACV, 341
- Setting
 - Integration time, 92, 104
 - line voltage switches, 35
- Setup, triggering, 159
- SHIFT annunciator, 48
- Shipping instructions, 41
- Single
 - integer, 140
 - readings, 128
- Single real, 141
- SINT
 - example, 151
 - output format, 151
- SLOPE, 342
- SMATH, 343
- SMPL annunciator, 48
- specify, 95
- Specifying
 - AC voltage method, 100
 - bandwidth, 103
 - integration time directly, 93
 - measurement function, 83
 - power line cycles, 92
 - range, 85
 - ratio measurements, 110
 - resolution, 94, 106
- Specifying Resolution, when to, 107
- SREAL
 - example, 142
 - output format, 153
- SRQ, 48, 345
 - annunciator, 48
- SSAC, 345
- SSDC, 345
- SSPARM?, 350
- SSRC, 351
- SSTATE, 355
- Standard
 - queries, 62
 - query commands, 228
- Stands, tilt, 39
- State
 - memory, using, 116
 - power-on, 46
- State key
 - recall, 57

- store, 57
- Statement
 - ENTER, 70
 - OUTPUT, 70
 - TRANSFER, 70
- Statements, Input/output, 70
- States
 - deleting, 117
- Statistics, 184
- Status register, 119
 - reading the, 120
- STB?, 357
- Store State key, 57
- Storing
 - states, 116
 - subprogram, 111
- SUB, 358
- SUBEND, 361
- Subprogram
 - execution, suspending, 112
 - memory, using, 111
 - storing, 111
- Subprograms
 - compressing, 114
 - nested, 113
- Sub-Sampling, 209
- Sub-sampling, 212
 - fundamentals, 209
 - remarks, 212
- Suspending
 - readings, 81
 - subprogram execution, 112
- SWEEP, 362
- Switch
 - lockout caps, 419
 - power, 46
- Switches, setting the line voltage, 35
- Sync source event, 211
- Synchronous
 - ACDCV example, fast, 161
 - ACV example, fast, 161
 - readings, 130
 - sampling conversion, 99
 - sampling remarks, 99

T

- T, 365
- TALK annunciator, 48
- Talk Only Mode, 237
- TARM, 365
- TBUFF, 368
- TEMP?, 369
- Temperature, measuring, 189
- TERM, 370
- Terminals, selecting the input, 78
- Termination
 - command, 226
 - output, 151
- TEST, 371
- Test key, 53
- test, display, 55
- tilt stands, 39
- Time, delay, 159
- Timed readings, 131
- TIMER, 371
- TONE, 373
- Transfer
 - across GPIB, high-speed, 163
 - from memory, high-speed, 165
- TRANSFER statement, 70
- TRIG, 373
- Trig key, 57
- Trigger
 - arming multiple, 129
 - buffering, external, 135
 - event, 126
- Triggering
 - examples, level, 197
 - external, 134
 - level, 197
 - measurements, 125
 - setup, 159
- Two's complement binary coding, 141

U

- USER keys, 67
- User-defined keys, 67

Using

- configuration keys, 57
- DINT output format, 151
- DREAL output format, 154
- implied read, 148
- Input buffer, 118
- MENU keys, 61
- reading memory, 144
- reading numbers, 146
- SINT output format, 151
- SREAL output format, 153
- state memory, 116
- status register, 119
- subprogram memory, 111

V

- Values, default, 59
- Verification, installation, 39
- Viewing Long Displays, 65
- Voltage
 - AC, 98
 - AC + DC, 98
 - limits, line, 35
 - method, specifying the AC, 100
 - switches, setting the line, 35

W

- Warranty repairs, 41
- Waveform, aperture, 172



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Keysight 3458A Multimètre

Guide
d'utilisation

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Informations relatives à la sécurité

ATTENTION

La mention ATTENTION signale un danger. Si la manœuvre ou la procédure correspondante n'est pas exécutée correctement, il peut y avoir un risque d'endommagement de l'appareil ou de perte de données importantes. En présence de la mention ATTENTION, il convient de ne pas poursuivre tant que les conditions indiquées n'ont pas été parfaitement comprises et remplies.

AVERTISSEMENT

La mention AVERTISSEMENT signale un danger pour la sécurité de l'opérateur. Si la manœuvre ou la procédure correspondante n'est pas exécutée correctement, il peut y avoir un risque grave, voire mortel pour les personnes. En présence d'une mention AVERTISSEMENT, il convient de s'interrompre tant que les conditions indiquées n'ont pas été parfaitement comprises et satisfaites

Symboles de sécurité

Les symboles suivants portés sur l'instrument et contenus dans sa documentation indiquent les précautions à prendre afin de garantir son utilisation en toute sécurité.

	Courant continu (CC)		Courant alternatif (CA)
	Attention, danger d'électrocution		Attention, risque de danger (reportez-vous à ce manuel pour des informations détaillées sur les avertissements et les mises en garde)
	Terminal conducteur de protection		Borne du cadre ou du châssis

Consignes de sécurité

Lisez les informations ci-dessous avant d'utiliser cet instrument.

Les consignes de sécurité présentées dans cette section doivent être appliquées dans toutes les phases de l'utilisation, de l'entretien et de la réparation de cet équipement. Le non-respect de ces précautions ou des avertissements spécifiques mentionnés dans ce manuel constitue une violation des normes de sécurité établies lors de la conception, de la fabrication et de l'usage normal de l'instrument. Keysight Technologies ne saurait être tenu pour responsable du non-respect de ces consignes.

AVERTISSEMENT

- **MISE A LA TERRE DE L'INSTRUMENT:** Pour réduire les risques de choc électrique, le châssis et la baie de l'instrument doivent être reliés à la terre.
- **NE PAS UTILISER L'APPAREIL DANS UN ENVIRONNEMENT EXPLOSIF:** N'utilisez pas cet appareil en présence de gaz inflammables ou de fumée. Le fonctionnement de tout appareil électrique dans un tel environnement présente un danger.
- **NE PAS TOUCHER AUX CIRCUITS:** Les utilisateurs ne sont pas autorisés à retirer les couvercles de l'instrument. Le remplacement des pièces et les réglages internes doivent être réalisés par des techniciens qualifiés. Dans certaines conditions, des tensions dangereuses subsistent dans l'appareil même lorsque le câble d'alimentation est déconnecté. Pour éviter tout risque de blessures accidentelles, débranchez toujours l'instrument et déchargez les circuits avant de les toucher.
- **NE PAS PROCEDER A UN ENTRETIEN OU A UN REGLAGE SEUL:** N'essayez pas de procéder à un entretien ou à un réglage interne sans la présence d'une autre personne, capable de porter les premiers secours et avertie des techniques de réanimation.
- **NE REMPLACER AUCUN COMPOSANT ET NE MODIFIER PAS L'INSTRUMENT:** Compte-tenu des risques d'accident, ne remplacez aucun composant et ne procédez à aucune modification non autorisée de l'instrument. Pour toute maintenance et/ou réparation, retournez l'appareil à un bureau commercial ou à un service après-vente Keysight ou les consignes de sécurité seront strictement observées.

AVERTISSEMENT

- **NE PAS UTILISER UN INSTRUMENT ENDOMMAGÉ:** Des lors que les dispositifs de sécurité inhérents à cet instrument ont été endommagés (par un choc physique, un excès d'humidité ou toute autre raison), **DEBRANCHEZ** l'instrument et ne l'utilisez pas tant qu'un technicien qualifié n'a pas vérifié son état de fonctionnement. Si nécessaire, retournez l'appareil à un bureau commercial ou à un service après-vente Keysight ou les consignes de sécurité seront strictement observées.
 - Pour prévenir toute électrocution, déconnectez l'instrument de l'alimentation secteur et tous les cordons de test avant de commencer le nettoyage. Nettoyez les parties externes de l'instrument à l'aide d'un chiffon doux non pelucheux légèrement humidifié avec de l'eau. N'utilisez PAS de détergent ou de solvant. NE tentez AUCUN nettoyage interne.
Si nécessaire, contactez un bureau de ventes et de service après-vente Keysight Technologies pour organiser un nettoyage approprié afin de garantir la préservation des caractéristiques de sécurité et de performance.
-

ATTENTION

Cet appareil de mesure est sensible de par sa conception et une exposition à des phénomènes électromagnétiques ambiants continus peut engendrer des pertes de performances.

Conditions ambiantes

Ce 3458A est conçu pour être utilisé dans des locaux fermés où la condensation est faible. Le tableau ci-dessous illustre les conditions d'environnement générales requises pour cet instrument.

Condition d'environnement	Exigences
Température	Conditions de fonctionnement – de 0 à 55 °C
Humidité	Conditions de fonctionnement – Jusqu'à 95% d'humidité relative à 40 °C (sans condensation) – Jusqu'à 40 % HR de 41°C à 55°C (sans condensation)
Altitude	Jusqu'à 2000 m
Degré de pollution	2
Catégorie d'installation	II
Mesure de catégorie de tension	II
Protection contre le survolage	II
Conditions d'alimentation	100/120 V, 220/240 V $\pm$ 10 % 48 - 66 Hz, 360 - 420 Hz automatiquement détectée < 30 W, < 80 VA (crête) Sous fusible : 1,5 à 115 V ou 0,5 A à 230 V

AVERTISSEMENT

N'UTILISEZ PAS L'INSTRUMENT DANS UNE ATMOSPHÈRE EXPLOSIVE OU DANS DES ENVIRONNEMENTS HUMIDES

N'utilisez pas l'instrument à proximité de gaz ou de vapeurs inflammables, de vapeurs ou dans d'environnements humides.

Conformité et réglementation des produits

Le multimètre numérique 3458A est conforme aux exigences de sécurité et de CEM.

Reportez-vous à la Déclaration de conformité pour

<http://www.keysight.com/go/conformity> connaître la dernière révision.

Directive européenne 2002/96/CE relative aux déchets d'équipements électriques et électroniques (DEEE)

Cet instrument est conforme aux exigences de marquage de la directive relative aux DEEE (2002/96/CE). L'étiquette apposée sur le produit indique que vous ne devez pas jeter ce produit électrique ou électronique avec les ordures ménagères.

Catégorie du produit:

en référence aux types d'équipement définis à l'Annexe 1 de la directive DEEE, cet instrument est classé comme «instrument de surveillance et de contrôle».

L'étiquette apposée sur l'appareil est celle représentée ci-dessous.



Ne le jetez pas avec les ordures ménagères.

Si vous souhaitez retourner votre instrument, contactez le Centre de services Keysight le plus proche ou consultez le site Web <http://about.keysight.com/en/companyinfo/environment/takeback.shtml> pour de plus amples informations.

Support technique et commercial

Pour contacter Keysight pour obtenir un support technique et commercial, consultez les liens d'assistance des sites Web Keysight suivants:

- www.keysight.com/find/3458A
(informations et support spécifiques au produit, mises à jour logicielles et documentation)
- www.keysight.com/find/assist
(informations de contact dans le monde entier pour les réparations et le support)

Préface

Ce manuel contient des informations relatives au fonctionnement, à la programmation et à la configuration du multimètre 3458A. Il se décompose comme suit:

Chapitre 1 Installation et maintenance

Ce chapitre traite de l'inspection initiale, de l'installation et de la maintenance du 3458A. Il renferme également la liste des options et des accessoires disponibles.

Chapitre 2 Présentation du multimètre

Ce chapitre décrit les principes de fonctionnement de base du multimètre. Il explique comment utiliser le panneau avant de l'instrument, comment envoyer des commandes au multimètre depuis un ordinateur distant ou consulter les données qu'il renferme à distance.

Chapitre 3 Configuration de l'instrument

Ce chapitre explique comment configurer le multimètre pour tous les types de mesures exception faite de la numérisation (qui fait l'objet d'un chapitre distinct - voir chapitre 5). Il vous apprendra également à utiliser la mémoire de sous-programme et d'état, la mémoire-tampon d'entrée ainsi que le registre d'état.

Chapitre 4 Mesures

Ce chapitre traite des différentes méthodes de déclenchement des mesures ainsi que des formats de lecture: il vous explique comment utiliser la mémoire de lecture et transférer les lectures par le bus GPIB. Vous y apprendrez également comment accroître la vitesse de lecture, comment utiliser le signal EXTOUT et les fonctions mathématiques du multimètre.

Chapitre 5 Numérisation

Le principe de la numérisation consiste à convertir un signal analogique continu en une série d'échantillons discrets (lectures). Ce chapitre traite des différentes méthodes de numérisation des signaux, de l'importance de la vitesse d'échantillonnage et explique comment utiliser les déclenchements par niveau.

Chapitre 6 Référence

Ce chapitre présente le langage utilisé par le multimètre (HPML) et donne une description détaillée de chacune de ses commandes. Les commandes sont classées par ordre alphabétique.

Annexes

Les annexes contiennent les spécifications du multimètre, les commandes GPIB reconnues par l'instrument, des informations sur le verrouillage des borniers avant/arrière ainsi que des notes relatives à la numérisation et à l'optimisation de la vitesse et du débit de lecture du multimètre.

Table des matières

U.S. Government Restricted Rights	3
Symboles de sécurité	4
Consignes de sécurité	5
Directive européenne 2002/96/CE relative aux déchets d'équipements électriques et électroniques (DEEE)	7
Catégorie du produit:	7
Support technique et commercial	7
Préface	8
1 Installation et maintenance	
Introduction	26
Inspection initiale	27
Options et accessoires	28
Installation du multimètre	30
Mise à la terre	30
Caractéristiques d'alimentation	31
Réglage des sélecteurs de tension secteur	31
Installation du fusible d'alimentation secteur	32
Cordons d'alimentation	33
Connexion de l'interface GPIB	34
Spécification de l'adresse GPIB	35
Montage du multimètre	35
Vérification de l'installation	35
Maintenance	36
Remplacement du fusible d'alimentation	36
Remplacement d'un fusible de mesure de courant	36
Pour faire réparer votre instrument	37
2 Initiation	
Introduction	42
Avant de mettre sous tension	43

Mise sous tension	44
Test automatique de mise sous tension	44
Etat de mise sous tension	44
L'affichage	46
Utilisation à partir du panneau avant	47
Les mesures	48
Changement de la fonction de mesure	49
Réglage de la gamme manuel et automatique	50
Le test automatique complet	51
Lecture de registre d'erreur	52
Réinitialisation du multimètre	53
Utilisation des touches de configuration	55
Utilisation des touches MENU	60
Commandes d'interrogation	61
Contrôle de l'affichage	62
Chiffres affichés	64
Rappel	65
Touches définies par l'utilisateur	65
Installation du cache du clavier	67
Commande à distance	69
Instructions d'entrée/sortie	69
Lecture de l'adresse GPIB	69
Changement de l'adresse GPIB	70
Envoi d'une commande à distance	70
Obtention de données à partir du multimètre	70
La touche LOCAL	71

3 Configuration pour les mesures

Introduction	74
Configuration générale	75
Test automatique	75
Lecture des registres d'erreur	75
Etalonnage	76
Choix des bornes d'entrée	78
Entrées blindées	80

Suspension des lectures	81
Préconfiguration du multimètre	81
Spécification d'une fonction de mesure	83
Gamme automatique	84
Spécification de la gamme	85
Configuration pour des mesures de tension, de courant continu ou de résistance	86
Tension continue	86
Courant continu	87
Résistance	89
Configuration du convertisseur A/N (analogique/ numérique)	91
Auto-zéro	95
Compensation de décalage	96
Impédance d'entrée fixe	96
Configuration pour les mesures alternatives	98
Tension alternative ou alternative + continue	98
Courant alternatif ou alternatif + continu	101
Fréquence ou période	102
Spécification de la largeur de bande	103
Spécification du temps d'intégration	104
Spécification de la résolution	107
Configuration pour les mesures de rapport	110
Spécification des mesures de rapport	111
Utilisation de la mémoire de sous-programme	112
Sauvegarde d'un sous-programme	112
Exécution d'un sous-programme	113
Suspension de l'exécution d'un sous-programme	113
Sous-programmes emboîtés	114
Sous-programme d'auto-démarrage	115
Compression des sous-programmes	115
Suppression des sous-programmes	116
Utilisation de la mémoire d'état	117
Sauvegarde des états	117
Rappel des états	118

Suppression des états	118
Utilisation de la mémoire-tampon d'entrée	119
Utilisation du registre d'état	120
Lecture du registre d'état	121
Interruptions	122

4 Les mesures

Introduction	126
Déclenchement des mesures	127
L'événement d'armement de déclenchement	128
L'événement de déclenchement	128
L'événement d'échantillonnage	128
Choix d'événements	128
Lectures continues	129
Lectures uniques	131
Lectures multiples	133
Armement multiple	133
Lectures synchrones	135
Lectures à intervalles réguliers	136
Lectures à retardement	137
Déclenchements externes	138
Combinaisons d'événements	139
Formats de lecture	142
ASCII	148
Entier simple et long	148
Réel simple	149
Utilisation de la mémoire de lecture	152
Formats de mémoire	152
Rappel des lectures	154
Transfert des lectures par le bus GPIB	158
Formats de sortie	158
Fin de transmission	160
Utilisation du format de sortie SINT ou DINT	160

Utilisation du format de sortie SREAL	162
Utilisation du format de sortie DREAL	164
Augmentation de la vitesse de lecture	166
Mode grande vitesse	166
Configuration pour lectures rapides	167
Transfert à grande vitesse par le bus GPIB	175
Transfert à grande vitesse à partir de la mémoire	177
Détermination de la vitesse de lecture	178
Le Signal EXTOUT	181
Lecture terminée	183
Groupe de lectures terminées	184
Entrée terminée	185
Signal d 'ouverture	186
Demande de service	186
EXTOUT ONCE	187
Opérations mathématiques	189
Temps réel ou différé	189
Validation des opérations mathématiques	189
Registres mathématiques	191
NULL	192
SCALE	194
Pourcentage	195
DB	197
DBM	198
Statistiques	200
Pass/Fail (Réussite/Echec)	201
FILTER	204
RMS	205
Mesure de température	206

5 Numérisation

Introduction	210
Méthodes de numérisation	211
Vitesse d'échantillonnage	213
Déclenchement par niveau	215

Exemples de déclenchement par niveau	215
Filtre de niveau	219
Numérisation de tensions continues	220
Remarques relatives aux mesures de tension continue	221
Exemple DCV	223
Echantillonnage direct	225
Remarques sur l'échantillonnage direct	226
Exemple d'échantillonnage direct	227
Sous-échantillonnage	229
Principe du sous-échantillonnage	229
L'événement Source de synchronisation	231
Remarques relatives au sous-échantillonnage	233
Transfert des échantillons en mémoire	235
Envoi des échantillons au contrôleur	236
Visualisation des données échantillonnées	239

6 Référence

Introduction	244
Langage du multimètre	246
Conventions de langage	246
Envoi des commandes	247
Commandes multiples	248
Paramètres	248
Commandes d'interrogation	249
Commandes par groupe fonctionnel	252
Commandes et fonctions de mesure	254
ACAL	256
ACBAND	258
ACDCI, ACDCV, ACI, ACV	260
ADDRESS	260
APER	261
ARANGE	262
AUXERR?	263
AZERO	266

BEEP	267
CAL	268
CALL	268
CALNUM?	269
CALSTR	270
COMPRESS	271
CONT	273
CSB	273
DCI, DCV	274
DEFEAT	274
DEFKEY	275
DELAY	277
DELSUB	278
DIAGNOST	280
DISP	280
DSAC, DSDC	281
EMASK	285
END	287
ERR?	288
ERRSTR?	289
EXTOUT	291
FIXEDZ	293
FREQ	294
FSOURCE	296
FUNC	297
ID?	302
INBUF	303
ISCALE?	304
LEVEL	308
LFILTER	310
LFREQ	311
LINE?	312
LOCK	313
MATH	314
MCOUNT?	317
MEM	318
MENU	319

MFORMAT	321
MMATH	323
MSIZE	327
NDIG	328
NPLC	329
NRDGS	332
OCOMP	336
OFORMAT	337
OHM, OHMF	344
OPT?	344
PAUSE	345
PER	347
PRESET	349
PURGE	351
QFORMAT	352
R	354
RANGE	354
RATIO	358
RES	359
RESET	362
REV?	364
RMATH	364
RMEM	366
RQS	368
RSTATE	369
SCAL	370
SCRATCH	370
SECURE	370
SETACV	373
SLOPE	374
SMATH	375
SRQ	378
SSAC, SSDC	378
SSPARM?	383
SSRC	384
SSTATE	389
STB?	391

SUB	392
SUBEND	396
SWEEP	396
T	400
TARM	400
TBUFF	403
TEMP?	404
TERM	405
TEST	406
TIMER	406
TONE	408
TRIG	408

A Spécifications

B Commandes GPIB

Introduction	414
ABORT 7 (IFC)	415
CLEAR (DCL or SDC)	415
LOCAL (GTL)	416
LOCAL LOCKOUT (LLO)	416
REMOTE	417
SPOLL (scrutation série)	418
TRIGGER (GET)	419

C Procédure de verrouillage des commutateurs des bornes avant/arrière et de la borne de protection

Introduction	422
Outils nécessaires	423
Procédure	424
Retrait des couvercles de l'instrument	424
Retrait de la tige-poussoir de Guard	427
Retrait de la tige-poussoir avant/arrière	427
Installation des caches-commutateur	431
Installation des couvercles de l'instrument	433

CETTE PAGE EST BLANCHE INTENTIONNELLEMENT.

List of Figures

Figure 1-1	Panneau arrière	30
Figure 1-2	Positions des sélecteurs de tension secteur	32
Figure 1-3	Cordons d'alimentation secteur	33
Figure 1-4	Interconnexion GPIB typique	34
Figure 1-5	Module borne/fusible	37
Figure 2-1	Panneau avant	47
Figure 2-2	Mesures 2-fils standard (avec entrées protégées)	48
Figure 2-3	Touches FUNCTION	49
Figure 2-4	Test de l'affichage	54
Figure 2-5	Fonctions des touches de configuration	55
Figure 2-6	Cache du clavier (référence 03458-84303))	67
Figure 2-7	Installation du cache du clavier	68
Figure 3-1	Connexions de mesure de tension	87
Figure 3-2	Connexions de mesure de courant	88
Figure 3-3	Connexions de mesure de résistance 2-fils	90
Figure 3-4	Connexions de mesure de résistance 4-fils	91
Figure 3-5	Connexions pour les mesures de rapport	110
Figure 4-1	Hierarchie des déclenchements	127
Figure 4-2	Armement d'un déclenchement multiple	134
Figure 4-3	Intervalle TIMER ou SWEEP	137
Figure 4-4	DELAY avec SWEEP (ou TIMER)	138
Figure 4-5	Relations entre les événements et le convertisseur A/N	182
Figure 4-6	Utilisation d'un scanner externe	184
Figure 5-1	Numérisation d'une onde sinusoïdale	210
Figure 5-2	Méthodes de numérisation	211
Figure 5-3	Numérisation du signal et connexions de mesure	212
Figure 5-4	Distortion causée par un sous-échantillonnage	213
Figure 5-5	Déclenchement au passage du signal par 0 volt, avec une pente positive	215
Figure 5-6	Déclenchement à 50%, pente négative, couplage CA	217
Figure 5-7	Déclenchement à -50%, pente positive, couplage CA	218

Figure 5-8	Déclenchement à -25%, pente positive, couplage CC .. 219
Figure 5-9	Echantillonnage direct 225
Figure 5-10	Exemple de sous-échantillonnage 230
Figure 5-11	Signal composite 231
Figure 5-12	Signal de synchronisation typique pour la source sync EXT 232
Figure 5-13	Tracé d'un signal typique 240
Figure C-1	Côté droit du 3458A 424
Figure C-2	Côté gauche du 3458A 425
Figure C-4	Vue arrière du 3458A 426
Figure C-3	Vis de mise à la masse du couvercle 426
Figure C-5	Face inférieure du 3458A 428
Figure C-6	Emplacement du commutateur GUARD et de sa tige-poussoir 429
Figure C-7	Face supérieure du 3458A 430
Figure C-8	Emplacement du commutateur des bornes avant/arrière et de sa tige-poussoir 432
Figure C-9	Installation des caches sur les commutateurs 433

List of Tables

Table 1-1	Options disponibles	28
Table 1-2	Accessoires disponibles	28
Table 1-3	Limites de tension secteur	31
Table 1-4	Capuchons et fusibles d'alimentation de remplacement	36
Table 2-1	Etat de mise sous tension	44
Table 2-2	Indicateurs d'affichage	46
Table 3-1	Tension d'entrée	80
Table 3-2	Etat PRESET NORM	82
Table 3-3	Paramètres des fonctions de mesure	84
Table 3-4	Gammes de tensions continues	86
Table 3-5	Gammes de courants continus	88
Table 3-6	Gammes de résistances	89
Table 3-7	Méthodes de mesure des tensions alternatives et alternatives + continues	99
Table 3-8	Gammes de courants alternatifs et alternatifs+ continus et résolution	102
Table 3-9	Paramètres de la commande FSOURCE	103
Table 3-10	Relations entre le convertisseur A/N et les mesures CA analogiques	107
Table 3-11	Temps de porte et Résolution des mesures de fréquence/période	108
Table 4-1	Paramètres d'événements	129
Table 4-2	Combinaisons d'événements	142
Table 4-3	Commandes exécutées par PRESET FAST	168
Table 4-4	Registres mathématiques	191
Table 4-5	Registres STAT	200
Table 4-6	Fonctions de mesure de température	206
Table 5-1	Méthodes de numérisation	211
Table 5-2	Erreur d'amplitude et résolution par rapport à l'ouverture	222
Table 6-1	Commandes et fonctions de mesure	254
Table B-1	Fonctions GPIB	414

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1 Installation et maintenance

Introduction	26
Inspection initiale	27
Options et accessoires	28
Installation du multimètre	30
Maintenance	36

Introduction

Ce chapitre présente le Keysight 3458A, et explique comment déballer et installer l'instrument et le mettre sous tension. Il contient également des informations de maintenance, les spécifications, et les listes des options et accessoires disponibles. Lisez complètement les informations d'installation avant d'effectuer les connexions électriques et de mettre sous tension le Keysight 3458A.

Inspection initiale

AVERTISSEMENT

Si l'un des symptômes suivants apparaît ou est suspecté, retirez le 3458A du service. N'utilisez pas l'instrument tant que son fonctionnement n'a pas été vérifié par un personnel qualifié:

- Dommages visibles.
- Mauvaises conditions de transport.
- Stockage prolongé dans des conditions peu favorables.
- Fonctions défectueuses.

Si nécessaire, renvoyez le 3458A au Bureau commercial Keysight le plus proche pour maintenance et réparation afin de faire vérifier les fonctions de sécurité.

Le multimètre a été soigneusement contrôlé avant son départ d'usine. Il devrait donc être en bon état de fonctionnement à la réception. Vérifiez cependant qu'il n'a subi aucun dommage en cours de transport. Lors du déballage, vérifiez également que le multimètre est accompagné des documents et accessoires suivants, en plus du présent manuel de fonctionnement:

- Cordon d'alimentation secteur (quantité 1)
- Fusibles d'alimentation de rechange : 500 mA T (quantité 1 pour 220/240 opérations), 1,5 A NTD (quantité 1 pour 100/120 opérations)
- Superposition clavier (quantité 5)
- Capuchons de verrouillage de commutateur (quantité 2)
- Kit de cordons de test (quantité 1)

Si le multimètre est endommagé ou incomplet, avertissez immédiatement le bureau commercial Keysight Technologies le plus proche.

Options et accessoires

Les options et les accessoires disponibles pour le multimètre sont indiqués dans les [tableau 1-1](#) et [tableau 1-2](#), respectivement.

Tableau 1-1 Options disponibles

Description	Numéro de l'option	Référence pour installation sur le site
Mémoire de lecture étendue (jusqu'à 148 Ko)	001	03458-87901
Référence de haute stabilité (4 ppm/an)	002	03458-80002
Bibliothèque d'analyse de signaux	005	03458-80005
Kit de poignées avant	907	5061-9688
Kit de montage en baie	908	5061-9674
Kit de montage en baie (avec poignées)	909	5061-9675
2 ans de garantie supplémentaires (retour à Keysight)	W30	

Tableau 1-2 Accessoires disponibles

Description	Modèle ou référence
Manuel d'utilisation, Aide-mémoire et manuel d'étalonnage supplémentaires	03458-90403
Aide-mémoire supplémentaire	03458-90005
Manuel d'étalonnage supplémentaire	03458-90015
Cache pour touche définie par l'utilisateur	03458-84303
Cache de verrouillage de commutateur (1)	03458-44103
Câble GPIB de 1 mètre	10833A
Câble GPIB de 2 mètres	10833B
Câble GPIB de 4 mètres	10833C
Câble GPIB de 0,5 mètre	10833D
Jeu de cordons de test	34118A

Tableau 1-2 Accessoires disponibles

Description	Modèle ou référence
Paire de cordons de test à faible conductibilité thermique, cosse à cosse, 0,9 m	11053A
Paire de cordons de test à faible conductibilité thermique, cosse à fiche banane, 0,9 m	11174A
Paire de cordons de test à faible conductibilité thermique, fiche banane à fiche banane, 0,9 m	11058A
Sonde de détection RF	34301A
Sonde Haute tension CA/CC 40 kV	34300A
Sonde Haute tension (1 MHz) CA/CC 5kV	34119A
Sonde de courant CA/CC à pince	34302A
Jeu de sondes Kelvin (4 fils de 1 m chaque)	11059A
Jeu de clips Kelvin (2 par jeu)	11062A
Sonde de température	34303A
Thermistance 2252 Ω	40653A
Thermistance 5 k Ω	40653B
Thermistance 10 k Ω	40653C
Sonde RTD en acier inoxydable 100 Ω , $\alpha = 0,00385$	40654A
RTD pour montage en surface, $\alpha = 0,00385$	40654B

Installation du multimètre

Ce paragraphe décrit les caractéristiques d'alimentation du Keysight 3458A et explique comment procéder à l'installation de votre multimètre. (Pour l'installation des caches de verrouillage des commutateurs, voir l'[annexe C](#)). La [figure 1-1](#) décrit le panneau arrière du multimètre. La fonction de la plupart des connecteurs et commutateurs du panneau arrière est expliquée dans le présent chapitre.

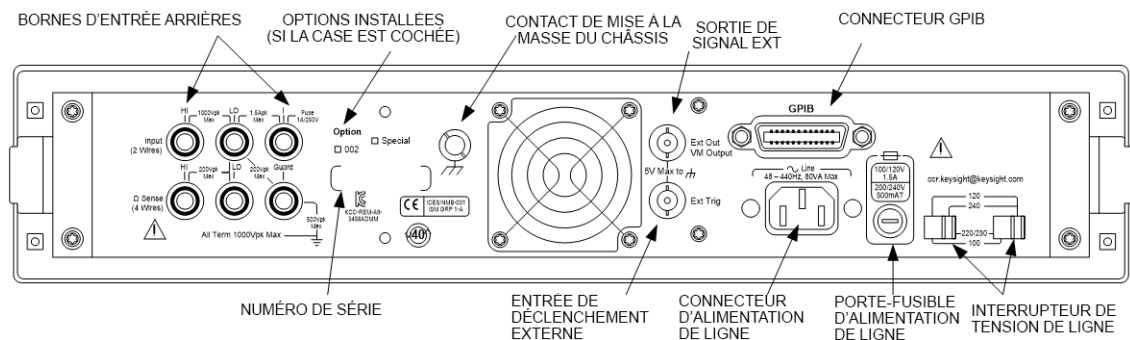


Figure 1-1 Panneau arrière

Mise à la terre

Le Keysight 3458A est fourni avec un cordon secteur à 3 conducteurs (voir [figure 1-3](#)). Ce cordon doit être branché dans une prise électrique à trois contacts réglementaire dont l'un est connecté à une terre électrique (terre de sécurité). Le connecteur d'alimentation et le cordon fournis avec le multimètre satisfont aux normes de sécurité de la Commission Électrotechnique Internationale (IEC).

AVERTISSEMENT

Pour éviter tout risque de choc électrique, le fil de terre du cordon d'alimentation doit impérativement être connecté à une terre électrique.

Caractéristiques d'alimentation

Vous pouvez alimenter le multimètre à partir d'une source alternative monophasée délivrant 100 V, 120 V, 220 V ou 240 V (efficaces) entre 48 et 440 Hz. Les valeurs de tension indiquées peuvent varier de $\pm 10\%$ mais la dernière ne doit pas dépasser 250 V efficaces. La consommation maximale est de 80 V A. Les tensions nominales et leurs limites correspondantes sont indiquées au [tableau 1-3](#).

ATTENTION

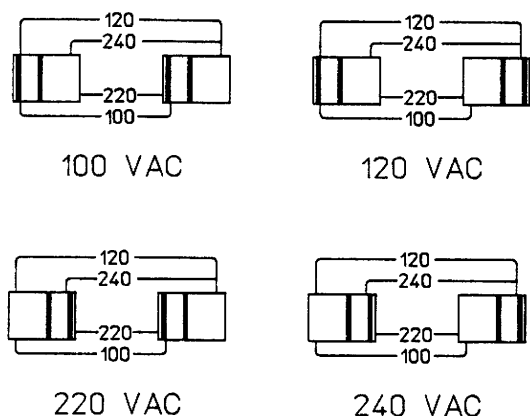
Avant de connecter le Keysight 3458A à une source d'alimentation secteur, vérifiez que cette source d'alimentation correspond au réglage du sélecteur de tension secteur du Keysight 3458A et que l'instrument est muni du fusible adéquat.

Tableau 1-3 Limites de tension secteur

Valeur nominale (Eff.)	Limites autorisées (Eff.)
100 Vca90	Vca à 110 Vca
120 Vca108	Vca à 132 Vca
220 Vca198	Vca à 242 Vca
240 Vca216	Vca à 250 Vca

Réglage des sélecteurs de tension secteur

Si vous devez changer les positions des sélecteurs de tension secteur, éteignez le Keysight 3458A et débranchez-le. Puis, avec un petit tournevis à lame plate, configurez les sélecteurs comme indiqué [figure 1-2](#).



0ME10134580P00F.12

Figure 1-2 Positions des sélecteurs de tension secteur

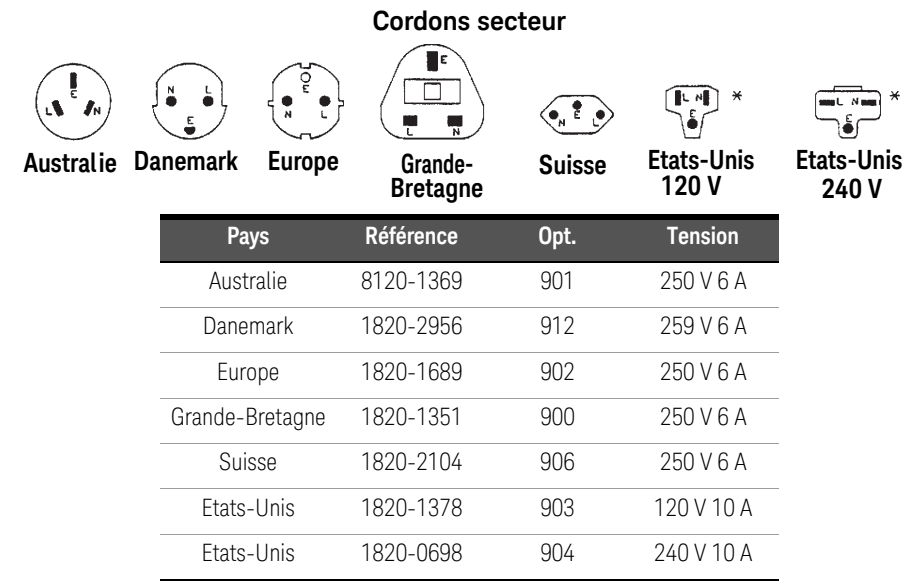
Installation du fusible d'alimentation secteur

Le fusible d'alimentation secteur du Keysight 3458A n'est pas installé en usine, mais deux fusibles sont fournis avec le multimètre. Pour une utilisation en 100 V ca ou 120 V ca, installez le fusible de 1,5 A. Pour une utilisation en 220 V ca ou 240 V ca, installez le fusible 500 mA.

Le porte-fusible est situé sur le côté droit du panneau arrière du Keysight 3458A (voir [figure 1-1](#)). Avant d'installer un fusible, vérifiez que le cordon secteur du multimètre est bien débranché. Insérez une extrémité du fusible dans le capuchon puis l'ensemble dans le porte-fusible. Avec un petit tournevis à lame plate, poussez le capuchon et tournez dans le sens horaire.

Cordons d'alimentation

La **figure 1-3** illustre les différents cordons d'alimentation secteur Keysight et leurs références Keysight. Si le cordon fourni n'est pas le bon, prévenez votre bureau commercial Keysight pour qu'il procède à son remplacement.



Les cordons fournis par Keysight ont des polarités qui correspondent à celles du connecteur d'alimentation de l'instrument

- L = Ligne ou conducteur actif
- N = Conducteur neutre ou identifié
- E = Terre de sécurité

Remarque: les prises sont vues par leur extrémité. Leur forme extérieure peut varier pour un pays donné.

*Seules ces prises sont certifiées CSA.

Figure 1-3 Cordons d'alimentation secteur

Connexion de l'interface GPIB

Fixez le câble GPIB^[1] au connecteur GPIB 24 broches du panneau arrière du Keysight 3458A. Serrez à la main les deux vis du connecteur de câble. La **figure 1-4** présente une interconnexion typique entre le multimètre et un contrôleur.

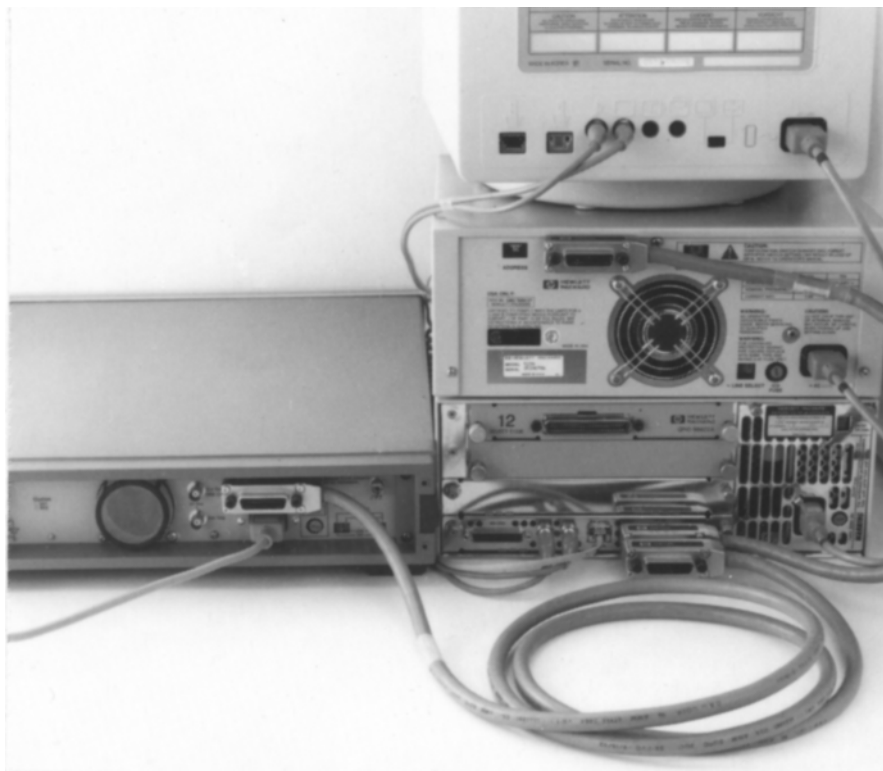


Figure 1-4 Interconnexion GPIB typique

Vous pouvez connecter jusqu'à 15 périphériques sur le même bus d'interface GPIB. Les câbles comportent des connecteurs mâle/femelle à chaque extrémité et il est donc possible d'empiler plusieurs câbles sur un même instrument.

[1] GPIB (bus d'interface Hewlett-Packard) est la mise en œuvre par Hewlett-Packard des normes IEEE 488-1978 et ANSI MC1.1

Cependant, la longueur totale des câbles GPIB *ne doit pas* dépasser 20 mètres au total, ou 2 mètres par instrument (la plus petite longueur des deux).

Spécification de l'adresse GPIB

Vous pouvez changer l'adresse GPIB du Keysight 3458A en utilisant la commande ADDRESS. Référez-vous au paragraphe **Chapitre 2, « Changement de l'adresse GPIB »**. Le Keysight 3458A quitte l'usine préconfiguré sur l'adresse 22 (décimal). Le code -ASCII correspondant est une adresse de réception de 6 et une adresse d'émission de V.

REMARQUE

Les exemples figurant dans ce manuel se rapportent à des ordinateurs Hewlett-Packard séries 2001300 utilisant le langage HP BASIC. Le code de sélection de l'interface GPIB par défaut est 7 et l'adresse de l'instrument 22, ce qui donne l'adresse GPIB 722.

Montage du multimètre

Le Keysight 3458A est équipé de quatre pieds et deux supports inclinables en place: et peut être utilisé sur une table. La face avant du Keysight 3458A peut être surélevée en étendant les supports inclinables. Le Keysight 3458A peut également être monté dans une baie 19 pouces standard à l'aide des kits de montages en baie optionnels (voir **tableau 1-1**).

Vérification de l'installation

Le programme ci-après vérifie que le multimètre est opérationnel et peut communiquer avec le contrôleur par le bus GPIB.

```
10 PRINTER IS 1
20 OUTPUT 722;"ID?"
30 ENTER 722; IDENT$
40 PRINT IDENT$
50 END
```

Si le multimètre a été correctement installé, le message **Keysight 3458A** s'imprimera sur l'imprimante système spécifiée. Si aucun message ne s'imprime, vérifiez que le multimètre est bien sous tension. Vérifiez également les connexions GPIB, l'adresse de l'interface et celle du multimètre.

Maintenance

Cette partie indique comment remplacer les fusibles du multimètre et la procédure à suivre pour une réparation.

Remplacement du fusible d'alimentation

Le porte-fusible est situé sur le côté droit du panneau arrière du Keysight 3458A (voir [figure 1-1](#)). Avant de remplacer un fusible, vérifiez que le cordon secteur du multimètre est bien débranché. A l'aide d'un petit tournevis à lame plate, appuyez sur le capuchon du fusible et tournez dans le sens anti-horaire. Retirez le capuchon et remplacez le fusible par un fusible de calibre approprié (voir [tableau 1-4](#)). (Le capuchon du fusible d'alimentation gris porte la référence 2110-0565). Réinstallez le capuchon et remettez l'instrument sous tension.

Tableau 1-4 Capuchons et fusibles d'alimentation de remplacement

Tension secteur	Fusible d'alimentation secteur
100 ou 120 V ca (Nominal)	1,5 A, NTD, réf. Keysight 2110-0043
220 ou 240 V ca (Nominal)	500 mA SB, réf. Keysight 2110-0202

Remplacement d'un fusible de mesure de courant

Les bornes de courant avant et arrière de l'instrument (marqués 1) renferment toutes deux un fusible de mesure de courant. Pour accéder au fusible, dévissez à fond (sens anti-horaire) la molette de la borne de courant. Appuyez sur la borne et tournez dans le sens horaire. Le module borne/fusible peut alors être retiré comme illustré à la [figure 1-5](#). Si nécessaire, remplacez le fusible par un fusible 1A 250V NTD (référence Keysight 2110-0001). (ATTENTION: N'utilisez jamais un fusible à fusion lente comme fusible de mesure de courant; sinon, vous risquez d'endommager l'instrument). Remplacez le module borne/fusible dans son logement et vissez-le dans le sens horaire jusqu'à ce qu'il soit bloqué.

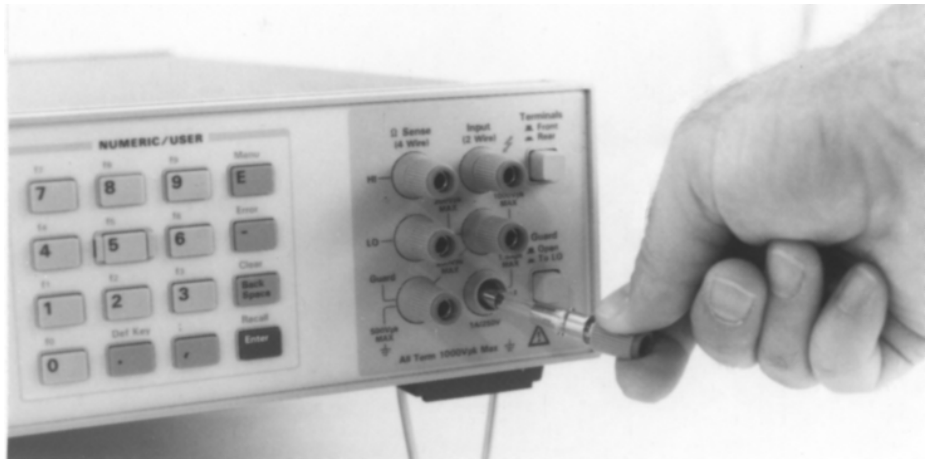


Figure 1-5 Module borne/fusible

Pour faire réparer votre instrument

Vous pouvez faire réparer votre Keysight 3458A dans un centre de maintenance Keysight, qu'il soit sous garantie ou non. Après la période de garantie, les réparations seront facturées. Contactez votre bureau commercial Keysight pour les instructions d'expédition avant de renvoyer l'instrument. Une liste des bureaux commerciaux est donnée à la fin de ce manuel.

Numéro de série

Les instruments Keysight sont identifiés par un numéro de dix chiffres en deux parties, de la forme 0000A00000. Les quatre premiers chiffres sont les mêmes pour tous les produits identiques. Ils ne changent qu'en cas de modification du produit. La lettre indique le pays d'origine. Un A indique que le produit a été fabriqué aux États-Unis. Les cinq derniers chiffres sont propres à chaque instrument. Le numéro de série du Keysight 3458A est situé à droite du bornier arrière.

Instructions d'expédition

Si vous devez expédier votre Keysight 3458A, assurez-vous qu'il est correctement emballé (canons et matériaux de protection d'origine) pour qu'il ne soit pas endommagé en cours de transport. Les dommages ne sont pas couverts par la

garantie. Fixez une étiquette à l'envoi, indiquant le nom et l'adresse du propriétaire et le type de maintenance ou de réparation demandé. Spécifiez le modèle et le numéro de série du multimètre. Il est fortement conseillé de faire assurer le transport.

2 Initiation

Introduction	42
Avant de mettre sous tension	43
Mise sous tension	44
Utilisation à partir du panneau avant	47
Commande à distance	69

Introduction

Ce chapitre s'adresse aux utilisateurs peu familiarisés avec les multimètres. Il explique les fonctions du panneau avant de l'instrument, comment envoyer des commandes au multimètre depuis un ordinateur distant et comment récupérer les mesures du multimètre à distance. La première partie (utilisation à partir du panneau avant) traite également de sujets importants tels que état de mise sous tension, indicateurs d'affichage mais aussi comment sélectionner ou entrer les paramètres et comment mesurer une tension continue simple. C'est la raison pour laquelle il est conseillé de lire le chapitre en entier même si vous n'avez l'intention de n'utiliser le multimètre qu'en mode de commande à distance.

Avant de mettre sous tension

- Assurez-vous que les sélecteurs de tension secteur sont configurés correctement.
- Vérifiez la présence du bon fusible.

En cas de doutes relatifs à l'installation ou aux caractéristiques d'alimentation, relisez le [chapitre 1](#).

Mise sous tension

Pour mettre le Keysight 3458A sous tension, appuyez sur l'interrupteur POWER du panneau avant. Si votre multimètre ne s'allume pas, vérifiez qu'il est bien branché. Dans l'affirmative, débranchez-le et vérifiez le fusible d'alimentation secteur et les réglages des sélecteurs de tension secteur.

Test automatique de mise sous tension

Le test automatique de mise sous tension vérifie que le Keysight 3457 fonctionne mais ne vérifie pas nécessairement que les mesures seront précises.

Etat de mise sous tension

A la fin de la séquence de mise sous tension, le Keysight 3458A fait entendre un bip, déclenche automatiquement, sélectionne automatiquement la gamme et effectue des mesures de tension continue. Par ailleurs, le Keysight 3458A a configuré un certain nombre de ses commandes à des valeurs prédéfinies comme illustré dans le [tableau 2-1](#). C'est ce qu'on appelle l'état de mise sous tension.

Tableau 2-1 Etat de mise sous tension

Commande	Description
ACBAND 20, 2E6	Largeur de bande CA 20 Hz-2 MHz
AZERO ON	Auto-zéro validé
DCV AUTO	Tension CC, réglage de gamme automatique
DEFEAT OFF	Invalidation de la protection des entrées
DELAY -1	Retard par défaut
DISP ON	Affichage validé
EMASK 32767	Conditions d'erreur toutes validées
END OFF	Fonction EOI (GPIB) invalidée
EXTOUT ICOMP, NEG	Entrée du signal EXTOUT terminée, impulsion négative
FIXEDZ OFF	Impédance d'entrée fixe invalidée

Tableau 2-1 Etat de mise sous tension (suite)

Commande	Description
FSOURCE ACV	La source de fréquence et de période est une tension alternative
INBUF OFF	Mémoire-tampon d'entrée invalidée
LEVEL 0, AC	Déclenchement par niveau: 0%, couplage CA
LFILTER OFF	Filtre de niveau invalidé
LOCK OFF	Clavier validé
MATH OFF	Fonctions mathématiques en temps réel invalidées
MEM OFF	Mémoire de lecture invalidée (dernière opération de mémoire = FIFO)
MFORMAT SREAL	Format de la mémoire de lecture: réel simple
MMATH OFF	Fonctions mathématiques de post-traitement invalidées
NDIG 7	Affichage de 7,5 chiffres
NPLC 10	10 périodes secteur comme temps d'intégration
NRDGS 1, AUTO	La lecture par déclenchement, événement d'échantillonnage AUTO
OCOMP OFF	Compensation du décalage de résistance invalidée
OFORMAT ASCII	Format de sortie ASCII
QFORMAT NORM	Format d'interrogation normal
RATIO OFF	Mesures de rapport invalidées
SETACV ANA	Mode de tension CA analogique
SLOPE POS	Pente positive pour un déclenchement à niveau
TARM AUTO	Événement d'armement de déclenchement automatique
TBUFF OFF	Mémoire-tampon des déclenchements externes invalidée
TIMER 1	Intervalle de 1 seconde entre les mesures
TRIG AUTO	Événement de déclenchement automatique
DEGREE = 20 REF = 1 SCALE = 1 RES = 50 PERC = 1	

L'affichage

Dans l'état de mise sous tension, l'affichage est continuellement mis à jour à chaque nouvelle lecture de tension CC. En bas de l'affichage apparaît une série d'indicateurs qui vous signalent certaines conditions. L'indicateur **SMPL** par exemple clignote pour indiquer la fin d'une mesure. Le [tableau 2-2](#) décrit la signification de chacun de ces indicateurs d'affichage.

Tableau 2-2 Indicateurs d'affichage

Indicateur	Description
SMPL	Clignote lorsqu'une mesure est terminée.
REM	Allumé lorsque le multimètre est commandé à distance par le bus GPIB.
SRQ	Allumé quand le multimètre a généré une demande de service (GPIB)
TALK	Allumé lorsque le multimètre est adressé pour Émettre (GPIB).
LSTN	Allumé lorsque le multimètre est adressé pour Recevoir (GPIB).
AZERO OFF	Allumé quand l'auto-zéro est invalidé.
MRNG	Allumé quand le changement de gamme automatique est invalidé (le multimètre utilise une gamme fixe).
MATH	Allumé si une ou deux fonctions mathématiques (temps réel ou post-traitement) sont actives.
ERR	Signale la détection d'une erreur.
SHIFT	Allumé lorsque la touche SHIFT a été enfoncée.
MORE INFO	Des informations supplémentaires concernant la configuration sont disponibles (appuyez sur la touche marquée d'une flèche vers la droite pour les faire défiler).

REMARQUE

Si le voyant **ERR** clignote, le Keysight 3458A a détecté une erreur pendant ou après le test automatique de mise sous tension. Se reporter au paragraphe [Lecture de registre d'erreur](#), plus loin dans ce chapitre pour plus de détails.

Utilisation à partir du panneau avant

Cette partie décrit comment mesurer simplement une tension CC, l'utilisation des différentes touches du panneau avant et décrit les fonctions du multimètre accessibles à partir du panneau avant. Les caractéristiques du panneau avant sont illustrées à la [figure 2-1](#).

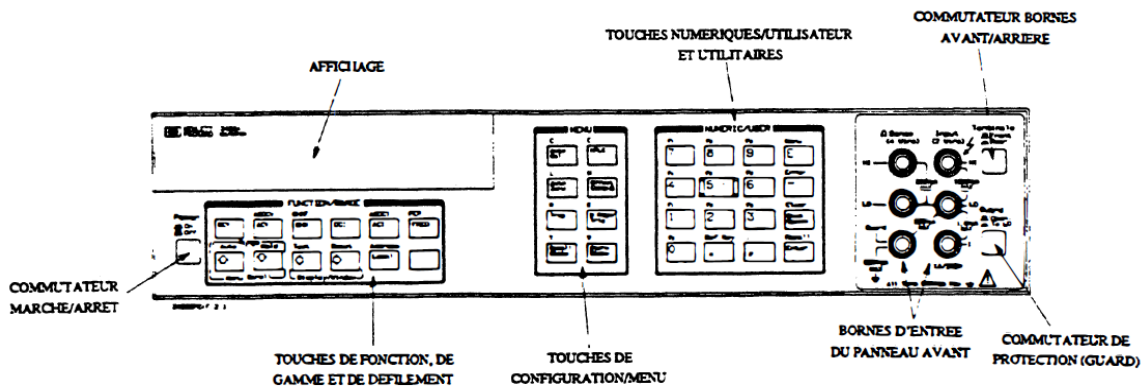


Figure 2-1 Panneau avant

Les mesures

En état de mise sous tension, le mode de mesure des tensions continues est sélectionné par défaut et le multimètre déclenche et sélectionne la gamme automatiquement. Pour mesurer une tension continue, il vous suffit alors de connecter le signal continu aux bornes d'entrée comme illustré à la [figure 2-2](#). Les connexions illustrées à la [figure 2-2](#) peuvent également être utilisées pour la mesure des tensions CA, des résistances 2-fils, des tensions CA+CC, des fréquences et des périodes ainsi que pour les mesures de numérisation. Les limites de courant et de tensions d'entrée maximales du multimètre figurent dans le [chapitre 3](#).

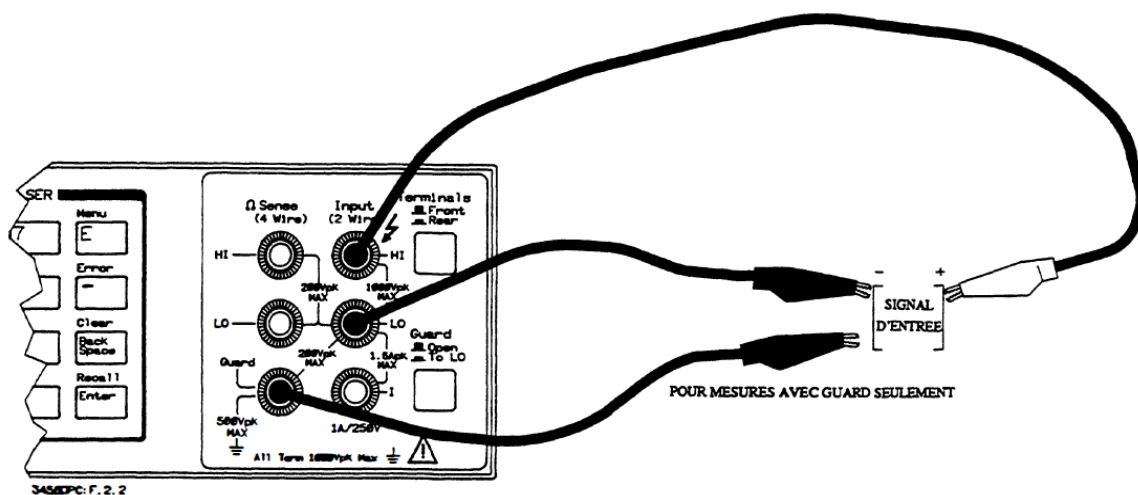


Figure 2-2 Mesures 2-fils standard (avec entrées protégées)

Changement de la fonction de mesure

La rangée de touches située immédiatement sous l'affichage (touches **FUNCTION**) vous permet de sélectionner une des fonctions de mesure standard du multimètre. Le [figure 2-3](#) indique la fonction de mesure correspondant à chacune de ces touches.

Touche	Description
	Mesures de tension continue
	Mesures de tension alternative
	Mesures de résistance 2-fils
	Mesures de courant continu
	Mesures de courant alternatif
	Mesures de fréquence
 	Mesures de tensions AC+CC
 	Mesures de résistance 4-fils
 	Mesures de courant CA+CC
 	Mesures de période

Figure 2-3 Touches FUNCTION

Outre les mesures sélectionnables par les touches **FUNCTION**, le Keysight 3458A peut effectuer des mesures de numérisation directement échantillonnées ou sous-échantillonnées, des mesures de rapport, ainsi que des mesures de tension CA ou CA+CC à l'aide de méthodes de mesure synchrones ou aléatoires. Ces fonctions sont sélectionnables par les touches MENU du panneau avant. (Ces touches sont décrites plus loin dans ce chapitre, voir [Utilisation des touches](#)

MENU). Pour plus de détails sur une fonction ou une méthode de mesure, se reporter au **chapitre 1** du présent manuel.

Réglage de la gamme manuel et automatique

Vous avez peut-être déjà remarqué qu'à l'état de mise sous tension, le Keysight 3458A sélectionnait automatiquement la gamme de mesure adéquate. C'est la fonction de gamme automatique. Dans la plupart des cas, cette fonction vous conviendra parfaitement. Vous disposez cependant de deux autres options; la gamme fixe et le réglage de gamme manuel.

Gamme fixe

Dans ces conditions, le 3458A choisit la gamme (fonction de gamme automatique) puis inactive la fonction de réglage automatique. L'instrument conserve ensuite la gamme choisie. Pour cette option, laissez l'instrument choisir une gamme puis appuyez sur:



REMARQUE

Lorsque vous appuyez sur la touche SHIFT (bleue), l'indicateur SHIFT s'allume. Le nom des fonctions accessibles par la touche SHIFT est écrit en bleu au-dessus des touches.

L'indicateur **MRNG** (gamme manuelle) de l'affichage s'allume. Cet indicateur est allumé à chaque fois que vous n'utilisez pas la gamme automatique.

Réglage de gamme manuel

Vous pouvez également sélectionner la gamme manuellement. Quand le 3458A est en mode mesure (il effectue et affiche des mesures ou l'affichage indique OVLD), vous pouvez modifier la gamme à l'aide des touches fléchées. Pour passer dans une gamme supérieure, appuyez sur:



La touche “flèche vers le haut” vous permet de configurer l'appareil dans les gammes supérieures. Une fois dans la gamme la plus haute, la touche est sans effet. Pour passer dans une gamme inférieure, appuyez sur:



La touche “flèche vers le bas” vous permet de configurer l'appareil dans les gammes inférieures. Une fois dans la gamme la plus basse, la touche est sans effet.:



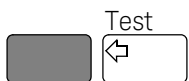
Le test automatique complet

Quand vous avez mis l'instrument sous tension, il a effectué automatiquement un test limité. Avant de commencer des mesures, il est possible, si vous le désirez, d'effectuer un test automatique plus complet. Le test automatique complet effectue une série de tests complète qui vérifie le fonctionnement et la précision du 3458A.

REMARQUE

Déconnectez toujours les signaux d'entrée éventuels avant d'exécuter le test automatique. Si un signal d'entrée est connecté au 3458A, le test risque d'échouer.

Le test automatique complet dure plus de 50 secondes. Pour exécuter ce test, appuyez sur les touches:



Si le test s'est exécuté sans erreur, l'affichage indique:

SELFTEST PASSED

Si aucune erreur n'a été détectée, vous pouvez raisonnablement être certain que le 3458A est complètement opérationnel et que les mesures seront précises.

Si par contre, l'un des tests échoue, l'indicateur **ERR** s'allume et l'affichage indique:

SELFTEST FAILED

Ce message signifie qu'une ou plusieurs conditions d'erreur ont été détectées. Référez-vous au paragraphe suivant [Lecture de registre d'erreur](#).

Lecture de registre d'erreur

Si le 3458A détecte une ou plusieurs erreurs, l'indicateur **ERR** s'allume. Les erreurs matérielles sont enregistrées dans un registre d'erreur auxiliaire. Les erreurs de programmation et de syntaxe sont enregistrées dans le registre d'erreur. Pour lire ce registre, appuyez sur:



L'erreur de plus bas numéro et sa description s'affichent. Exemple de message d'erreur:

**209, "HARDWARE FAILURE--
INTERNAL OVERLOAD: 101"**

Appuyez sur la touche [Flèche droite] pour faire défiler le message complet. Les erreurs de préfixe 100 (exemple: 105) sont des erreurs de syntaxe ou de programmation. Les erreurs de préfixe 200 sont des erreurs liées au matériel.

REMARQUE

En cas d'erreur matérielle (préfixe 200), relancez le test automatique. Si l'erreur se répète, il faut peut-être faire réparer votre multimètre.

Si l'indicateur ERR reste allumé, c'est que le multimètre a détecté d'autres erreurs. Répétez la séquence de touches ci-dessus jusqu'à ce que toutes les erreurs soient lues. Lorsque toutes les erreurs ont été lues, l'indicateur **ERR**

s'éteint. Si vous essayez de lire une autre erreur, l'affichage indique:

0, NO "ERROR"

Des erreurs peuvent apparaître également en dehors du test automatique. Le 3458A détecte les erreurs se produisant lors de l'entrée des données, quand vous changez de fonction ou de gamme, et ainsi de suite. Quand il détecte une erreur, le 3458A fait entendre un bip sonore.

Pour effacer des informations (telles qu'une description d'erreur) et revenir à l'affichage des mesures, appuyez sur:



REMARQUE

Vous pouvez également effacer l'affichage en appuyant répétitivement sur la touche [Retour arrière] (Backspace - sans Shift).

Réinitialisation du multimètre

Souvent, vous trouverez intéressant de pouvoir revenir à l'état de mise sous tension. Que ce soit à la suite d'une erreur dans l'entrée des commandes ou parce que vous voulez partir d'un état connu, la touche **RESET** du panneau avant vous renvoie à l'état de mise sous tension sans éteindre l'appareil. Pour réinitialiser le 3458A, appuyez sur:



La réinitialisation commence par un test de l'affichage: tous les éléments d'affichage s'allument, y compris les indicateurs illustrés à la [figure 2-4](#). (Si vous maintenez la touche **RESET** enfoncée, le test de l'affichage s'exécute en continu).

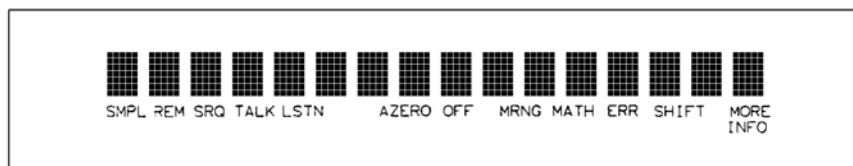


Figure 2-4 Test de l'affichage

ATTENTION

Le fait d'appuyer sur la touche (Shift)-Reset du panneau avant exécute la séquence de mise sous tension, ce qui équivaut à une mise hors/sous tension de l'instrument. Les mesures et les sous-programmes enregistrés sont effacés, le bit SRQ du registre d'état est mis à 1 (ces fonctions sont décrites plus loin dans ce chapitre), la fréquence de référence du convertisseur A/N est réinitialisée et le test de mise sous tension s'exécute. L'envoi d'une commande RESET à partir du menu de commandes alphabétiques (touches MENU) replace le multimètre à l'état de mise sous tension mais n'exécute pas la séquence de mise sous tension. Les touches MENU sont décrites plus loin dans ce chapitre.

Utilisation des touches de configuration

Les touches de configuration (touches MENU sans Shift) vous permettent d'accéder rapidement aux fonctions les plus couramment utilisées du multimètre. Le [figure 2-5](#) décrit chaque touche, la commande lui correspondant et sa fonction. (Ces fonctions sont décrites en détail dans les [chapitre 3](#) et [chapitre 4](#)).

Touche	Commande	Description
	ACAL	Exécute une ou toutes les routines d'auto-étalonnage. (L'exécution de toutes les routines prend 11 minutes. N'essayez jamais de réinitialiser le multimètre pour annuler un auto-étalonnage. Une fois l'auto-étalonnage programmé, il doit se poursuivre jusqu'à la fin).
	NPLC	Définit le temps d'intégration pour le convertisseur A/N en nombre de périodes secteur.
	AZERO	Valide ou invalide la fonction d'auto-zéro.
	OCOMP	Valide ou invalide la compensation de décalage des mesures de résistance 2 ou 4 fils.
	TRIG	Spécifie l'événement de déclenchement.
	NRDGS	Sélectionne le nombre de lectures (mesures) par événement de déclenchement et l'événement d'échantillonnage.
	RSTATE	Rappelle un état préalablement sauvegardé en mémoire.
	SSTATE	Sauvegarde l'état courant du multimètre en mémoire.

Figure 2-5 Fonctions des touches de configuration

Nous utiliserons la touche **Trig** pour illustrer l'utilisation des touches de configuration. Appuyez sur:



L'affichage indique:

TRIG ■■

C'est l'en-tête de la commande de déclenchement. Vous remarquerez que le 3458A place automatiquement un délimiteur (espace) après l'en-tête de commande.

Sélection d'un paramètre

Pour les paramètres qui proposent une liste de choix (paramètres non numériques), vous pouvez utiliser les touches [Flèche haut] et [Flèche bas] pour afficher les différents choix. Appuyez sur:



L'affichage indique:

TRIG LEVEL ■■

Appuyez sur:



L'affichage indique:

TRIG AUTO ■■

Si vous passez le dernier choix de paramètre, la touche fléchée (vers le haut ou vers le bas) boucle sur l'autre bout du menu. Supposons que vous vouliez suspendre un déclenchement. Appuyez sur la touche fléchée (vers le haut ou vers

le bas) jusqu'à ce que l'affichage indique:

TRIG HOLD ■■

Appuyez sur:

Enter

Ce faisant, vous avez fait passer l'événement de déclenchement de AUTO (état de mise sous tension) à HOLD, ce qui force le multimètre à interrompre les mesures. (Les fonctions de déclenchement sont décrites en détail dans le [chapitre 4](#).)

Valeurs par défaut

La plupart des paramètres ont une valeur par défaut. Le multimètre sélectionnera automatiquement cette valeur lorsque vous exécutez une commande sans spécifier de valeur. La valeur par défaut du paramètre de déclenchement par exemple est SGL. Appuyez sur:

Trig

L'affichage indique:

TRIG ■■

Appuyez sur:

Enter

Vous remarquerez que le multimètre effectue une mesure puis s'arrête (après le déclenchement unique, l'événement de déclenchement prend la valeur HOLD quel que soit l'événement de déclenchement préalablement spécifié). Vous pouvez également entrer -1 pour sélectionner la valeur par défaut Appuyez sur:

Enter - 1 Enter

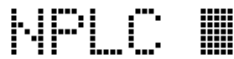
A nouveau, le multimètre effectue une mesure unique puis s'arrête.

Paramètres numériques

Certaines commandes utilisent des paramètres numériques. On appelle paramètre numérique la valeur effectivement utilisée par le multimètre. Nous utiliserons la touche de configuration **NPLC** pour illustrer le principe des paramètres numériques. Appuyez sur:



L'affichage indique:



Si vous appuyez sur une touche fléchée (vers le haut ou vers le bas), aucun choix de paramètre ne s'affichera. Cela signifie qu'il n'y a pas de menu et que vous devez entrer un nombre. Par exemple, appuyez sur:



Vous avez sélectionné 1 période secteur comme temps d'intégration pour le convertisseur A/N. Le temps d'intégration est le temps pendant lequel le convertisseur A/N mesure le signal d'entrée. (Le temps d'intégration est décrit en détail dans le [chapitre 3](#).)

Paramètres exponentiels

Vous pouvez aussi entrer des paramètres numériques en utilisant la notation exponentielle. Par exemple, appuyez sur:



Vous venez de sélectionner 0,1 période secteur comme temps d'intégration. A ce stade, vous pouvez réinitialiser le multimètre pour faire repasser le nombre de périodes secteur à 10 en appuyant sur:



Paramètres multiples

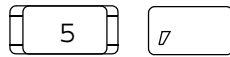
De nombreuses commandes ont plus d'un paramètre. (Les paramètres multiples doivent être séparés par des virgules). Nous utiliserons la commande NRDGS (nombre de lectures) qui a deux paramètres pour illustrer notre exemple. Appuyez sur:



L'affichage indique:

NRDGS ■■

Le premier paramètre de la commande NRDGS est un paramètre numérique qui spécifie le nombre de lectures (mesures) par événement de déclenchement. Pour spécifier 5 lectures par événement de déclenchement par exemple, appuyez sur:



L'affichage indique:

NRDGS 5, ■■

Le second paramètre de la commande NR.GDS spécifie l'événement qui déclenche la mesure. Les choix sont proposés sous forme de menu. Appuyez sur la touche fléchée (vers le haut ou vers le bas) jusqu'à ce que l'affichage indique:

NRDGS 5, AUTO ■■

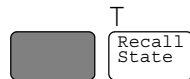
Exécutez la commande en appuyant sur:



Vous avez donc sélectionné 5 lectures par événement de déclenchement. Si vous exécutez la commande TRIG SGL par exemple, le multimètre effectuera cinq mesures puis s'arrêtera. (La commande NRDGS est décrite en détail dans le [chapitre 4](#).)

Utilisation des touches MENU

En plus des touches de configuration, le 3458A dispose d'un répertoire de commandes alphabétiques auxquelles vous pouvez accéder par les touches (Shift)-**MENU** intitulées C, E, L, N, R, S et T. Chacune de ces lettres correspond à l'endroit où vous entrerez dans le menu. Par exemple, pour entrer dans le menu des commandes commençant par T, appuyez sur:



L'affichage indique:

TARM ■■■

Vous pouvez maintenant utiliser les touches de défilement du menu (touches fléchées vers le haut ou vers le bas) pour appeler les commandes dans l'ordre alphabétique (flèche vers le bas) ou dans l'ordre inverse (flèche vers le haut). A supposer que TARM soit affiché (voir ci-dessus), si vous appuyez une fois sur la touche [Flèche bas], la prochaine commande dans l'ordre alphabétique (TBUFF) s'affichera. (Vous pouvez également maintenir les touches [Flèche bas] ou [Flèche haut] enfoncées pour vous déplacer rapidement dans le menu). Une fois la commande désirée affichée, vous pouvez appuyer sur Enter pour l'exécuter immédiatement (en utilisant la valeur par défaut des paramètres, si applicable). Si vous devez spécifier un ou plusieurs paramètres pour la commande affichée, appuyez sur la touche [Flèche droite] ou sur la touche [,] (ou encore, si le paramètre est de type numérique, sur une touche numérique). Ceci sélectionne la commande et vous permet de spécifier ou de sélectionner un ou des paramètre(s), comme indiqué précédemment.

Vous avez le choix entre deux menus alphabétiques: FULL et SHORT. Vous pouvez choisir l'un ou l'autre de ces menus à l'aide de la touche (Shift)-Menu. Votre choix est enregistré en mémoire permanente (il est conservé à la mise hors tension de l'instrument). Le menu FULL contient toutes les commandes, exceptées les commandes d'interrogation non standard (commandes à la suite desquelles vous ajoutez un point d'interrogation: exemple: BEEP, BEEP?). Les commandes d'interrogation sont décrites ci-après. Le menu SHORT élimine toutes les commandes en rapport avec le bus GPIB, les commandes rarement utilisées à partir du panneau avant et toutes les commandes directement accessibles par une touche du panneau avant (exemples: **NPLC**, **Trig**).

Commandes d'interrogation

Plusieurs commandes dans le répertoire alphabétique se terminent par un point d'interrogation. Ces commandes sont appelées commandes d'interrogation dans la mesure où chacune d'elles retourne une réponse à une question particulière. Par exemple, accédez à la commande LINE? du menu de commandes et appuyez sur la touche Enter. Le multimètre répond à cette question en affichant la fréquence de la tension d'alimentation après l'avoir mesurée. (Utilisez la touche [Flèche droite] pour visualiser la réponse en entier). Autre exemple: accédez à la commande TEMP? du menu de commandes et appuyez sur Enter. Cette commande d'interrogation renvoie la température interne du multimètre en degrés centigrades.

Interrogations standard

Le menu de commandes complet (FULL) contient les commandes d'interrogation standard suivantes:

AUXERR?MCOUNT?

CAL?MSIZE?

CALNUM?OPT?

ERR?REV?

ERRSTR?SSPARM?

ID?STB?

ISCALE?TEMP?

LINE?

Interrogations supplémentaires

Vous pouvez créer d'autres commandes d'interrogation en ajoutant un point d'interrogation à la fin de toutes les commandes servant à programmer le multimètre. La commande AZERO par exemple (touche de configuration **Auto Zero**) valide ou invalide la fonction d'auto-zéro. Pour savoir si cette fonction est validée ou non, vous pouvez ajouter un point d'interrogation à la commande AZERO. Pour ce faire, appuyez sur:



Le multimètre répond en affichant le mode d'auto-zéro courant (mode de mise sous tension= ON/validé). Vous remarquerez que cette commande s'exécute immédiatement; vous n'avez pas à appuyer sur la touche **Enter**).

REMARQUE

La commande QFORMAT peut être utilisée pour spécifier si la réponse à l'interrogation sera de type numérique, alphabétique ou alphanumérique. Pour plus de détails sur la commande QFORMAT, se reporter au [chapitre 6](#).

Contrôle de l'affichage

Les touches (Shift)-**Clear**, **Back Space** (espace arrière) et **Display/Window** (flèches vers la gauche et vers la droite) vous permettent de contrôler l'affichage.

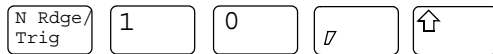
Effacement de l'affichage

Lorsque vous voulez effacer l'affichage (réponse à une question par exemple), appuyez sur:



Modification de l'affichage

La touche **Back Space** vous permet de modifier des portions d'une chaîne de commande pendant sa saisie ou lors de son rappel (fonctions décrites plus loin dans ce manuel). Pour les paramètres alphabétiques ou les en-têtes de commande, une seule pression sur la touche **Back Space** suffit à effacer entièrement le paramètre ou l'en-tête. Pour les virgules, les espaces et les paramètres numériques, un seul caractère est effacé à chaque fois que vous appuyez sur **Back Space**. Par exemple, appuyez sur:



L'affichage indique:

NRDGS 10. LINE ■■

Si vous appuyez une fois sur **Back Space**, le second paramètre (alphabétique) disparaît de l'écran. L'affichage indique:

NRDGS 10, ■■

Si vous appuyez une autre fois sur **Back Space**, la virgule est supprimée. Si vous appuyez deux autres fois sur **Back Space**, les deux caractères numériques (10) disparaissent. Vous pouvez alors redéfinir le premier paramètre à l'aide du clavier numérique puis le second, à l'aide des touches de défilement du menu. Pour finir, appuyez sur **Enter** pour exécuter la commande modifiée.

Visualisation d'affichage long

Lorsque vous saisissez des commandes comportant plus de 16 caractères, vous constaterez que les premiers caractères disparaissent à gauche de l'affichage pour vous permettre de poursuivre votre saisie. Les touches **Display/Window** (touches fléchées vers la gauche et vers la droite) vous permettent ensuite de faire défiler l'affichage vers la gauche ou la droite pour visualiser la ligne complète. Les touches **Display/Window** peuvent également être utilisées pour visualiser de longues chaînes telles que des messages d'erreur, la chaîne d'étalonnage (réponse à la commande CALSTR?) ou la définition des touches utilisateur (fonction décrite plus loin dans ce chapitre). Par exemple, appuyez sur:

N Rgds/
Trig 1 0 0 0 0 0 / ↵

L'affichage indique:

DGS 100000, LINE ■■

En appuyant sur la touche [Flèche gauche], vous pouvez visualiser la première partie de la commande tandis que la fin de la commande défile et disparaît vers la droite. Si maintenant vous appuyez sur la touche [Flèche droite], vous pouvez visualiser la fin de la commande alors que le début défile et disparaît vers la gauche.

REMARQUE

Imaginez l'affichage comme une fenêtre que vous pouvez déplacer vers la gauche ou la droite à l'aide des touches fléchées.

Visualisation des informations supplémentaires

Outre la possibilité de faire défiler l'affichage vers la gauche ou la droite, les touches **Display/Window** vous permettent de visualiser des informations supplémentaires signalées par l'indicateur **MORE INFO**. Par exemple, affichez et exécutez la commande SETACV RNDM du menu de commandes alphabétiques. Appuyez ensuite sur la touche ACV du panneau avant. Vous remarquerez que l'indicateur **MORE INFO** s'est allumé. Ceci signifie qu'il y a d'autres informations que celles affichées. Pour les connaître, appuyez sur:

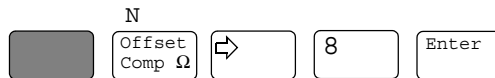


La méthode utilisée pour mesurer la tension CA (SET A VC RNDM) s'affiche. Pour remplacer le multimètre à son état de mise sous tension, appuyez sur:



Chiffres affichés

Quand le multimètre affiche des mesures, vous pouvez modifier le nombre de chiffres affichés. La valeur de mise sous tension est de 7,5 chiffres alors que l'instrument a une résolution de 8,5 chiffres. Pour afficher 8,5 chiffres, appuyez sur:



REMARQUE

Le 1/2 chiffre supplémentaire est toujours supposé lorsque vous spécifiez le nombre de chiffres à afficher.

La commande NDIG ne fait que masquer des chiffres de l'affichage. Elle n'affecte en aucune autre manière les mesures enregistrées en mémoire de lecture ou celles transmises par le bus GPIB. Par ailleurs, vous ne pouvez pas visualiser plus de chiffres que ne le permet la résolution de l'instrument.

Rappel

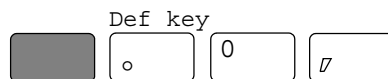
Vous pouvez facilement rappeler la dernière commande exécutée sans ressaisir la commande. Pour ce faire, appuyez sur:



L'affichage indique la dernière commande exécutée. (Vous ne pouvez pas rappeler des commandes qui s'exécutent immédiatement telles que **Reset** ou **DCV** ou des commandes d'étalonnage protégées par un code de sécurité). En répétant la séquence de touches ci-dessus, vous pouvez rappeler successivement toutes les commandes exécutées. Lorsque la commande désirée s'affiche, vous pouvez la modifier (comme indiqué dans le paragraphe "**Modification de l'affichage**") puis l'exécuter en appuyant sur **Enter**.

Touches définies par l'utilisateur

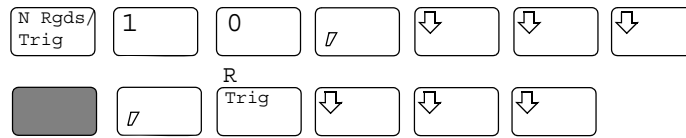
Vous pouvez affecter une chaîne de une ou plusieurs commandes à chacune des touches **USER** (libellées de **f0** à **f9**). Après avoir affecté une chaîne à une de ces touches (40 caractères maximum), il suffit de d'appuyer sur la touche pour que la chaîne s'affiche. Vous pouvez alors exécuter la chaîne en appuyant sur **Enter**. L'affectation des chaînes aux touches s'effectue à l'aide de la touche **Def Key**. Par exemple, pour affecter les commandes NRDGS 10,AUTO;TRIG SGL (le point-virgule sert à lier plusieurs commandes) à la touche **f0**, appuyez sur:



L'affichage indique:

```
DEFKEY 0, "NRDGS 10,AUTO;TRIG SGL"
```

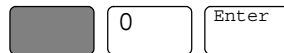
Vous pouvez alors entrer la chaîne de commandes en appuyant sur:



Pour sauvegarder la chaîne (c'est-à-dire l'affecter à la touche spécifiée sans qu'elle soit exécutée), appuyez sur:



Pour accéder à la chaîne affectée à la touche **f0** et l'exécuter, appuyez sur:



Le multimètre effectuera 10 mesures et s'arrêtera.

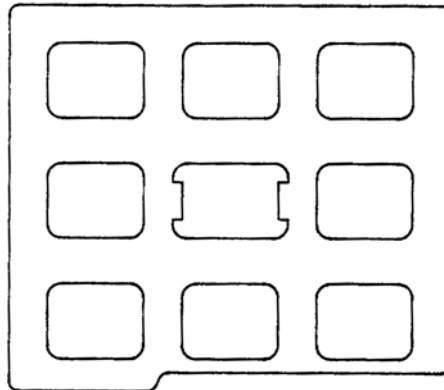
Une des caractéristiques du clavier vous permet d'accéder directement à la chaîne affectée à une touche sans utiliser la touche Shift (sauf lors de la saisie d'une chaîne). Par exemple, pour accéder à la chaîne affectée à la touche **f0** et l'exécuter, appuyez successivement sur:



Vous pouvez également affecter des commandes du menu de commandes à des touches définies par l'utilisateur, exceptions faites des commandes qui s'exécutent immédiatement telles que DCV ou ACV. On accède à ces commandes par le menu. Les définitions de touches sauvegardées à partir du panneau avant peuvent être modifiées à partir du panneau avant. (Par contre, vous ne pouvez pas modifier une définition de touche téléchargée depuis le contrôleur). Pour modifier le contenu d'une touche définie par l'utilisateur, il suffit d'appuyer sur la touche concernée et de modifier la chaîne lorsqu'elle s'affiche, comme indiqué au paragraphe "**Modification de l'affichage**". Une fois la chaîne modifiée, appuyez sur **Enter** pour l'exécuter. (La chaîne précédente est toujours affectée à la touche définie par l'utilisateur). Une chaîne modifiée ne peut pas être ré-affectée à une touche définie par l'utilisateur. Si vous voulez changer la définition d'une touche, vous devez répéter la procédure indiquée ci-dessus.

Installation du cache du clavier

La [figure 2-6](#) montre le cache qui se pose sur les touches **USER**. Vous pouvez écrire au crayon sur ce cache pour identifier la ou les commande(s) affectée(s) à chacune des touches.



34580PC: F. 2. 4

Figure 2-6 Cache du clavier (référence 03458-84303))

Le cache comporte deux encoches et est maintenu en place par deux petits onglets prévus de part et d'autre de la touche numérique **5**. Pour installer le cache, glissez d'abord l'encoche gauche sous l'onglet de gauche. Pliez légèrement le cache comme illustré à la [figure 2-7](#) et glissez l'encoche de droite sous l'onglet de droite.

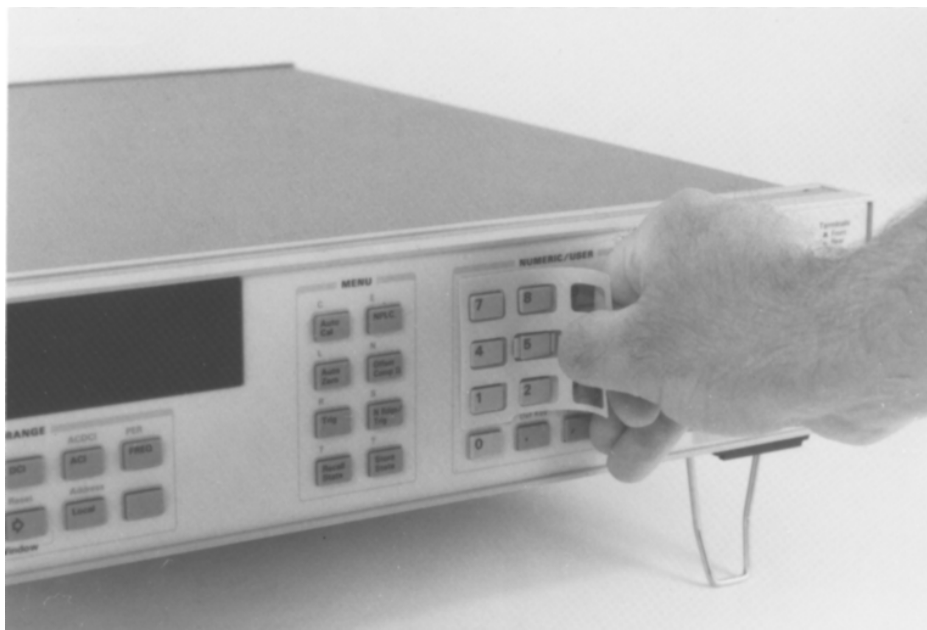


Figure 2-7 Installation du cache du clavier

Commande à distance

Cette partie explique le principe de commande du multimètre depuis un ordinateur distant. Elle vous apprend, entre autres, à lire et à modifier l'adresse GPIB, à envoyer une commande au multimètre et à interroger les données de l'instrument.

Instructions d'entrée/sortie

Les instructions utilisées pour commander le 3458A à distance dépendent de votre ordinateur et de son langage. En particulier, vous devez connaître les instructions que votre ordinateur utilise pour entrer et sortir des informations. Par exemple, l'instruction d'entrée pour un ordinateur utilisant le BASIC des séries 200/300 Hewlett-Packard est:

ENTER or TRANSFER

L'instruction de sortie est:

OUTPUT

Lisez les manuels de votre ordinateur pour connaître les instructions dont vous avez besoin. Les exemples utilisés dans ce manuel sont écrits principalement pour des ordinateurs Hewlett-Packard de la série 80 ou 200 utilisant le langage HP BASIC.

Lecture de l'adresse GPIB

Avant de pouvoir commander le 3458A à distance, vous devez connaître son adresse GPIB. L'adresse était affichée pendant la séquence de mise sous tension. Si vous ne vous en souvenez pas, appuyez sur:



Un affichage typique sera:

ADDRESS 22 ■■■

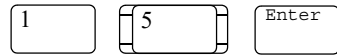
La réponse affichée est l'adresse du système. Quand vous envoyez une commande à distance, ajoutez cette adresse au code de sélection d'interface GPIB (normalement 7). Si, par exemple, le code de sélection est 7 et l'adresse du système 22, vous enverrez "722".

Changement de l'adresse GPIB

Chaque appareil raccordé au bus GPIB a une adresse unique. Si vous devez changer l'adresse du multimètre, accédez à la commande ADDRESS du menu de commandes (touches **MENU**). Lorsque l'affichage indique:

ADDRESS 

Vous pouvez entrer la nouvelle adresse. Par exemple, appuyez sur:



L'adresse du 3458A est maintenant 15. Pour revenir à l'adresse 22, répétez la procédure ci-dessus (ou appuyez sur la touche **Recall**) et spécifiez 22 en place de 15.

Envoi d'une commande à distance

Pour envoyer une commande à distance au 3458A, combinez l'instruction de sortie de votre ordinateur au code de sélection du GPIB, à l'adresse de l'instrument, et finalement, à la commande du 3458A. Par exemple, pour obtenir un beep, envoyez:

OUTPUT 722; "BEEP"

Remarquez que les indicateurs **REM** et **LSTN** de l'affichage sont allumés. Cela signifie que le multimètre est en mode de commande à distance et qu'il a été adressé pour Recevoir (une commande).

Obtention de données à partir du multimètre

Le 3458A peut envoyer les valeurs mesurées et les réponses aux interrogations qui lui sont posées. Par exemple, envoyez:

OUTPUT 722;"ID?"

Quand vous envoyez une interrogation à distance, le 3458A n'affiche pas la réponse comme il le faisait quand vous exécutiez la commande à partir de son panneau avant. Il envoie la réponse dans sa mémoire tampon de sortie. La mémoire tampon de sortie est un registre qui conserve l'information jusqu'à ce que celle-ci soit lue par l'ordinateur ou remplacée. Utilisez l'instruction ENTER de votre ordinateur pour extraire la réponse de la mémoire de sortie. Le programme suivant par exemple lit la réponse (3458A) et l'imprime.

```
10 ENTER 722;A$
```

```
20 PRINT A$
```

```
30 END
```

Vous utiliserez la même technique pour obtenir les lectures du multimètre à partir d'un ordinateur distant. A chaque fois que le multimètre effectue des mesures et que vous avez invalidé la mémoire de lecture (décrite au [chapitre 4](#)), vous pouvez obtenir le résultat en exécutant le programme suivant.

```
10 ENTER 722;A
```

```
20 PRINT A
```

```
30 END
```

La touche LOCAL

Si vous appuyez sur une touche du clavier du 3458A après l'avoir utilisé à distance, il ne répondra pas. En effet, le 3458A est en mode à distance (comme l'indique le voyant **REM** de l'affichage) et ignore son clavier. Pour le reconfigurer en mode local, appuyez sur:



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3 Configuration pour les mesures

Introduction	74
Configuration générale	75
Configuration pour des mesures de tension, de courant continu ou de résistance	86
Configuration pour les mesures alternatives	98
Configuration pour les mesures de rapport	110
Utilisation de la mémoire de sous-programme	112
Utilisation de la mémoire d'état	117
Utilisation de la mémoire-tampon d'entrée	119
Utilisation du registre d'état	120

Introduction

Ce chapitre vous montre comment configurer le multimètre pour tous les types de mesures exceptée la numérisation.^[1] Vous y apprendrez à utiliser la mémoire de sous-programme et d'état, la mémoire-tampon d'entrée et le registre d'état. Après avoir configuré votre multimètre en fonction de votre application comme indiqué dans ce chapitre, vous pourrez passer au chapitre suivant pour apprendre à déclencher les mesures et à les transférer dans la mémoire de lecture ou dans la mémoire-tampon de sortie GPIB. Ce chapitre se décompose comme suit:

- Configuration générale
- Configuration pour les mesures de résistance ou de courant continu
- Configuration pour les mesures alternatives
- Configuration pour les mesures de rapport
- Utilisation de la mémoire de sous-programme
- Utilisation de la mémoire d'état
- Utilisation de la mémoire-tampon d'entrée
- Utilisation du registre d'état

[1] Ce chapitre ne concerne pas la numérisation bien que la plupart des informations de **Configuration générale** s'applique à la numérisation. Pour plus de détails sur la numérisation, consultez le **chapitre 5**.

Configuration générale

Cette partie traite du test automatique du multimètre, des procédures d'étalonnage et du principe de configuration de l'instrument qui s'applique à de nombreuses fonctions de mesure sinon à toutes.

Test automatique

Avant de configurer l'instrument pour les mesures, il est conseillé d'exécuter le test automatique pour s'assurer que le multimètre fonctionne correctement. Le test dure environ 50 secondes. Pour le lancer, envoyez la commande:

OUTPUT 722;"TEST"

Si le test automatique s'exécute sans incidents, vous pouvez être assuré que le multimètre est opérationnel et que moyennant un étalonnage adéquat, il effectuera des mesures précises. Si un ou plusieurs tests échoue(nt), le multimètre positionne un ou plusieurs bits dans le registre d'erreur auxiliaire (il les met à 1), ce qui positionne automatiquement le bit 0 du registre d'erreur (anomalie matérielle) et allume l'indicateur **ERR** du panneau avant.

Lecture des registres d'erreur

Lorsqu'il détecte une erreur matérielle, le multimètre positionne un bit dans le registre d'erreur auxiliaire, ainsi que le bit 0 du registre d'erreur. S'il s'agit d'une erreur de programmation, le multimètre ne positionne qu'un seul bit - celui du registre d'erreur.

La commande **ERRSTR?** lit chaque erreur (une à la fois) puis remet le bit lui correspondant à 0. Si un ou plusieurs bits sont positionnés dans le registre d'erreur auxiliaire, la commande **ERRSTR?** lit d'abord ce registre avant de lire le registre d'erreur. La commande **ERRSTR?** renvoie deux réponses. La première correspond à la valeur décimale du bit positionné le moins significatif (poids le plus faible). La seconde réponse est un message (chaîne) expliquant l'erreur (200 caractères maximum). Après avoir lu un bit, la commande **ERRSTR?** le remet à 0.

Le programme suivant utilise la commande **ERRS1R?** pour lire toutes les erreurs (une à la fois). Après avoir lu tous les bits positionnés et les avoir remis à 0, ou si aucun bit n'était positionné dans aucun des deux registres d'erreur, la commande **ERRSTR?** renvoie 0, **"NO ERROR"**.

```

10 OPTION BASE 1           ! COMMENCE A 1
20 DIM A$(200)             ! DIMENSION DE LA VARIABLE ALPHANUMERIQUE
30 OUTPUT 722; "ERRSTR?"    ! LIT LE MESSAGE D'ERREUR
40 ENTER 722; A,A$          ! ECRIT LE NOMBRE DANS A, LA CHAINE DANS A$
50 PRINT A,A$              ! IMPRIME LES REPONSES
60 IF A>0 THEN GOTO 30      ! BOUCLE POUR LIRE CHAQUE ERREUR
70 END

```

Les commandes ERR? et AUXERR? renvoient la somme décimale de tous les bits positionnés dans le registre d'erreur et dans le registre d'erreur auxiliaire respectivement. Pour plus de détails sur ces commandes, voir [chapitre 6](#).

Etalonnage

Le Keysight 3458A offre deux formes d'étalonnage: l'étalonnage externe et l'étalonnage automatique. L'étalonnage externe implique une procédure utilisant des sources de référence externes. Pour plus de détails à ce sujet, se reporter au manuel d'étalonnage du Keysight 3458A (en anglais).

La commande d'interrogation CALNUM? renvoie le nombre d'étalonnages externes déjà effectués. En vérifiant régulièrement ce nombre, vous pouvez surveiller les étalonnages. Le programme ci-dessous lit et imprime le nombre d'étalonnages courant.

```

10 OUTPUT 722;"CALNUM?"
20 ENTER 722;A
30 PRINT A
40 END

```

Etalonnage automatique

Le multimètre dispose de quatre routines d'auto-étalonnage (autocal): DVC, AC, OHMS et ALL. Ces routines augmentent la précision à court terme de la plupart des fonctions de mesure mais ne doivent pas se substituer aux étalonnages externes périodiques requis par le multimètre. Les fonctions de mesure affectées par chacune de ces routines sont les suivantes:

- La routine DCV augmente la précision à court terme de toutes les fonctions de mesure. Elle s'exécute en 1 minute environ.

- La routine CA augmente la précision à court terme des mesures de tension alternative ou alternative+ continue (quelle que soit la méthode utilisée), des mesures de courant alternatif ou alternatif + continu. des mesures de numérisation directes ou sous-échantillonnées (couplage CA ou CC), des mesures de fréquence et de période. Elle s'exécute en 1 minute environ.
- La routine OHMS augmente la précision à court terme des mesures de résistance en mode 2 et 4 fils, des mesures de courant continu et de courant alternatif. Elle s'exécute en 10 minutes environ.
- La routine ALL augmente la précision à court terme de toutes les fonctions de mesure en exécutant toutes les routines mentionnées ci-dessus. Elle s'exécute en 11 minutes environ.

REMARQUE

Ne mettez pas l'instrument hors tension et ne le réinitialisez pas pendant qu'une routine if auto-étalonnage s'exécute. Dans ce cas, le multimètre génère l'erreur ACAL REQUIRED {puisque la plupart ou toutes ses constantes if auto-étalonnage ont été effacées) et vous devez exécuter la routine ALL (11 minutes) pour éliminer l'erreur.

Puisque la routine DCV s'applique à toutes les fonctions de mesure, il est conseillé de l'exécuter avant d'exécuter la routine AC ou OHMS ou encore la routine ALL (voir second exemple ci-dessous).

Exécution d'une routine d'auto-étalonnage

Supposons que vous apprêtiez à mesurer une résistance en mode 4-fils. La routine d'auto-étalonnage DCV augmente la précision à court terme de toutes les mesures et la routine OHMS celle des mesures de résistance (et de courant). Le programme suivant exécute la routine DCV puis la routine OHMS.

```
10 OUTPUT 722; "ACAL DCV"
20 OUTPUT 722; "ACAL OHMS"
30 END
```

Si la routine est protégée par un code (elle n'est pas protégée lorsqu'elle sort de l'usine), vous devez entrer le code de sécurité pour pouvoir l'exécuter. Pour plus de détails à ce sujet, voir commande ACAL dans le [chapitre 6](#). Vous

pouvez exécuter toutes les routines d'auto-étalonnage (DCV d'abord, suivie de OHMS et de AC) en envoyant la commande:

```
OUTPUT 722; "ACAL ALL"
```

Avant d'exécuter un étalonnage automatique, vous devez toujours déconnecter tous les signaux d'entrée. Tout signal d'entrée appliqué au multimètre risque d'affecter l'étalonnage automatique et toutes les mesures effectuées après.

Quand faut-il procéder à un étalonnage automatique?

Pour bénéficier d'une précision maximale, il est conseillé d'exécuter ACAL ALL toutes les 24 heures ou lorsque la température du multimètre change de ± 1 °C par rapport au dernier étalonnage externe ou automatique. (Il est également recommandé de sauvegarder la température d'étalonnage interne du multimètre à l'aide de la commande CALSTR; cette température pourra ainsi être relue plus tard à l'aide de la commande CALSTR?). L'exemple suivant montre comment utiliser la commande TEMP? pour surveiller la température interne (en °Celsius) du multimètre.

```
10 OUTPUT 722;"TEMP?"  
20 ENTER 722;A  
30 PRINT A  
40 END
```

Les constantes d'auto-étalonnage sont sauvegardées en mémoire permanente (elles ne sont pas perdues lors de la mise hors tension de l'instrument). Il n'est par conséquent pas nécessaire de procéder à un auto-étalonnage à chaque fois que le multimètre est remis sous tension.

Choix des bornes d'entrée

Le Keysight 3458A offre un jeu de bornes avant et arrière pour les connexions de mesure. Le commutateur Terminais du panneau avant vous permet de choisir entre les deux (enfoncé = bornes arrière; sorti = bornes avant). Vous ne pouvez pas sélectionner le bornier à distance. Les connexions de mesure illustrées dans ce chapitre n'utilisent que les bornes avant. Si vous utilisez les bornes arrière, connectez chaque fil à la borne portant le même nom qu'à l'avant. Il est vivement conseillé d'utiliser des câbles à haute impédance et faible absorption diélectrique pour toutes les connexions de mesure.

AVERTISSEMENT

- Seul un technicien qualifié, formé à la maintenance et parfaitement averti des risques encourus, est autorisé à retirer ou à installer le multimètre ou encore à procéder aux branchements. Mettez le multimètre hors tension et débranchez le cordon secteur de l'instrument à chaque fois que vous devez enlever un couvercle, modifier la position des sélecteurs de tension, installer ou remplacer un fusible d'alimentation secteur.
 - Mesurer des hautes tensions est toujours dangereux. Toutes les bornes d'entrée du multimètre (avant comme arrière) doivent être considérées comme dangereuses à chaque fois qu'un signal d'entrée supérieur à 42 V lui est appliquée. Considérez toujours toutes les bornes aussi dangereuses que celles sur lesquelles sont appliquées les plus hautes tensions.
 - Keysight recommande au câbleur de fi étiqueter toutes les bornes présentant des tensions dangereuses. Ces étiquettes, de couleur vive, devront être placées le plus près possible des bornes et les identifier sans ambiguïté. Elles devront clairement indiquer la présence éventuelle de hautes tensions.
-

ATTENTION

Le courant d'entrée maximal sur les bornes d'entrée avant et arrière (I) est de $\pm 1,5$ A avec un seuil maximal (sans dommage pour r appareil) de $<1,25$ A eff. Les entrées de courant sont protégées par fusible. Les tensions fi entrée maximales sont les suivantes:

Tableau 3-1 Tension d'entrée

	Tension d'entrée	Seuil maximal (sans dommage pour l'instrument)
Entre HI et LO INPUT	± 1000 V crête	± 1200 V crête
Entre HI/LO W Sense et LO	± 200 V crête	± 350 V crête
Entre HI et LO W Sense	± 200 V crête	± 350 V crête
Entre LO et GUARD	± 200 V crête	± 350 V crête
Entre GUARD et la terre	± 500 V crête	± 1000 V crête
Entre HI/LO INPUT, HI/LO W Sense ou une borne I et la terre	± 1000 V crête	± 1500 V crête
Entre bornes avant et arrière	± 1000 V crête	± 1500 V crête

Vous endommagerez le Keysight 3458A si vous appliquez des tensions supérieures aux seuils spécifiés ci-dessus.

Entrées blindées

Dans les connexions de mesure illustrées dans ce chapitre, la borne Guard est connectée à la borne LO de la source de mesure (mesures blindées). Cette configuration fournit un taux de réjection effectif de mode commun (EC:MR) maximal sur les bornes d'entrée sélectionnées par le commutateur Terminais, à condition que le commutateur Guard soit en position Open (sorti). Si vous ne souhaitez pas ce blindage, enfoncez le commutateur Guard (position To LO) et ne connectez pas la borne Guard à la source de mesure. Lorsqu'il est en position To LO, le commutateur Guard connecte de manière interne la borne Guard à la borne LO Input sur les bornes sélectionnées par le commutateur Terminais. Cette configuration fournit un ECMR réduit. Les spécifications de l'annexe A indiquent les taux de réjection effectifs de mode commun pour les mesures blindées. Il est

vivement conseillé d'utiliser des câbles à haute impédance et faible absorption diélectrique pour toutes les connexions de mesure.

Suspension des lectures

Dans l'état de mise sous tension du multimètre, les événements d'armement, de déclenchement et d'échantillonnage sont définis en mode AUTO (ces événements sont décrits en détail dans le [chapitre 4](#)). Ce qui signifie que le multimètre effectue continuellement des mesures. Avant de configurer le multimètre pour les mesures, il est conseillé de suspendre les lectures. La suspension des lectures diminue le temps requis pour la configuration et évite que des mesures indésirables ne soient enregistrées en mémoire de lecture ou dans la mémoire-tampon de sortie GPIB pendant la configuration. Vous pouvez suspendre les mesures en préconfigurant le multimètre (voir ci-dessous) ou en définissant l'événement d'armement ou de déclenchement en mode HOLD comme suit:

OUTPUT 722; "TARM HOLD"

ou

OUTPUT 722; "TRIG HOLD"

Après avoir configuré le multimètre, vous pouvez valider le mode de mesures en définissant l'événement d'armement ou de déclenchement à une autre valeur que HOLD. (Pour plus de détails sur le principe de déclenchement des mesures, se reporter au [chapitre 2](#)).

Préconfiguration du multimètre

La commande PRESET NORM est similaire à la commande RESET mais donne un bon point de départ pour configurer le multimètre en mode d'exploitation à distance. (RESET est avant tout une commande de panneau avant). Il est donc doublement intéressant de commencer à configurer le multimètre avec un PRESET NORM puisque non seulement cette commande fournit une configuration de départ mais encore elle suspend les lectures en utilisant SYN (commande TRIG SYN) comme événement de déclenchement. Le [tableau 3-2](#) montre les commandes exécutées par la commande PRESET NORM.

Tableau 3-2 Etat PRESET NORM

Commande	Description
ACBAND 20,2E+6	Largeur de bande CA 20 Hz - 2 MHz
AZERO ON	Auto-zéro validé
BEEP ON	Signal sonore validé
DCV AUTO	Tension CC, réglage de gamme automatique
DELAY -1	Retard par défaut
DISP ON	Affichage validé
FIXEDZ OFF	Impédance d'entrée fixe invalidée
FSOURCE ACV	La source de fréquence et de période est une tension alternative
INBUF OFF	Mémoire-tampon d'entrée invalidée
LOCK OFF	Clavier validé
MATH OFF	Fonctions mathématiques en temps réel invalidées
MEM OFF	Mémoire de lecture invalidée
MFORMAT SREAL	Format de la mémoire de lecture: réel simple
MMATH OFF	Fonctions mathématiques de post-traitement invalidées
NDIG 6	Affichage de 6,5 chiffres
NPLC 1	1 période secteur comme temps d'intégration
NRDGS 1,AUTO	1 lecture par déclenchement, événement d'échantillonnage AUTO
OCOMP OFF	Compensation du décalage de résistance invalidée
OFORMAT ASCII	Format de sortie ASCII
TARM AUTO	Événement d'armement de déclenchement automatique
TIMER 1	Intervalle de 1 seconde entre les mesures
TRIG SYN	Événement de déclenchement synchrone

A la mise sous tension, tous les registres mathématiques sont à 0, sauf:

DEGREE = 20

Tableau 3-2 Etat PRESET NORM

Commande	Description
PERC = 1	
REF = 1	
RES = 50	
SCALE = 1	

Lorsque vous essayez de préconfigurer le multimètre à partir d'un ordinateur distant, il se peut que le multimètre soit occupé ou que l'interface GPIB soit en attente. Dans l'un ou l'autre cas, le multimètre ne répondra pas immédiatement à la commande distante. La solution consiste à envoyer une commande (GPIB) Clear Device avant de préconfigurer l'instrument. Le multimètre répond immédiatement à une commande Clear Device. Le programme suivant envoie la commande Clear Device immédiatement suivie d'une commande de préconfiguration:

```
10 CLEAR 722
20 OUTPUT 722;"PRESET NORM"
30 END
```

Outre la commande PRESET NORM, le multimètre dispose d'une commande PRESET FAST (configuration pour des lectures et des transferts rapides) décrite dans le chapitre 4, et d'une commande PRESET DIG (configuration pour les numérisations DCV) décrite au chapitre 5.

Spécification d'une fonction de mesure

Le premier paramètre de la commande FUNC sélectionne la fonction de mesure. Par exemple, pour mesurer mie tension continue, envoyez:

```
OUTPUT 722;"FUNC DCV"
```

L'en-tête de la commande FUNC est optionnel et peut être omis. Vous pouvez par exemple spécifier des mesures de tension continu en envoyant:

```
OUTPUT 722;"DCV"
```

Les exemples donnés dans ce chapitre utilise la version abrégée (sans en-tête). Le tableau 3-3 indique les différents paramètres des fonctions de mesure et la fonction à laquelle ils correspondent

Tableau 3-3 Paramètres des fonctions de mesure

Paramètre de la fonction	Description
ACDCI	Sélectionne les mesures de courant alternatif, couplage CC
ACDCV	Sélectionne les mesures de tension alternative, couplage CC
ACI	Sélectionne les mesures de courant alternatif, couplage CA
ACV	Sélectionne les mesures de tension alternative, couplage CA
DCI	Sélectionne les mesures de courant continu
DCV	Sélectionne les mesures de tension continue
DSAC ^[a]	Echantillonnage direct, couplage CA
DSDC ^[a]	Echantillonnage direct, couplage CC
FREQ	Sélectionne les mesures de fréquence
OHM	Sélectionne les mesures de résistance 2-fils
OHMF	Sélectionne les mesures de résistance 4-fils
PER	Sélectionne les mesures de période
SSAC ^[a]	Sous-échantillonnage, couplage CA
SSDC ^[a]	Sous-échantillonnage, couplage CC

[a] Pour plus de détails sur ces fonctions, voir [Chapitre 5, « Numérisation »](#).

Gamme automatique

Lorsque la fonction de gamme automatique est validée, le multimètre échantillonne l'entrée avant chaque mesure (quand les mesures sont déclenchées), et sélectionne automatiquement la gamme correcte. Le fait d'échantillonner l'entrée ralentit les mesures. Dans les états de mise sous tension/PRESET NORM, la gamme automatique est validée. Si vous avez l'intention de mesurer un signal d'entrée relativement stable, vous pouvez utiliser la commande **ARANGE ONCE** pour que le multimètre sélectionne une seule fois la gamme automatique (quand les mesures sont déclenchées) et l'invalide pour les mesures suivantes. Vous bénéficiez ainsi de l'avantage de la gamme automatique et de la

vitesse des lectures, une fois la gamme automatique invalidée. Pour ce faire, envoyez:

OUTPUT 722; "ARANGE ONCE"

Dès que le déclenchement commence, le multimètre sélectionne la gamme correcte et invalide la fonction de gamme automatique. Si plus tard vous avez besoin de revalider la gamme automatique, envoyez:

OUTPUT 722; "ARANGE ON"

Spécification de la gamme

Vous pouvez spécifier une gamme fixe en utilisant le premier paramètre d'une des commandes de fonction (ACV, DCV, OHM, etc.) ou en utilisant la commande RANGE. Ce paramètre est appelé *max_input* (entrée max.) car il correspond à l'amplitude attendue maximale du signal d'entrée (ou la résistance maximale pour les mesures de résistance). Le multimètre choisit alors la gamme adéquate. Lorsque vous spécifiez *max_input*, utilisez toujours la valeur absolue du signal d'entrée – pas de nombres négatifs. Par exemple, pour spécifier une tension continue avec une entrée maximale de -2,5 volts, envoyez:

OUTPUT 722; "DCV 2.5"

Dans ce cas, le multimètre choisit la gamme 10 VCC. Pour spécifier une entrée max. différente (15 V par exemple) sans changer la fonction de mesure, envoyez:

OUTPUT 722; "RANGE 15"

Dans ce cas, le multimètre choisit la gamme 100 V.

REMARQUE

Pour les mesures de fréquence et de période, le paramètre d'entrée maximale spécifie l'amplitude maximale du signal d'entrée. Il ne spécifie ni la gamme de fréquences (Hz) ni celle des périodes (secondes).

Pour sélectionner la gamme automatique, prenez la valeur par défaut de l'entrée maximale ou spécifiez AUTO. Par exemple, pour sélectionner la gamme automatique avec la commande DCV, envoyez:

OUTPUT 722; "DCV"

Se reporter aux commandes FUNC ou RANGE du [chapitre 6](#) pour connaître les gammes de chaque fonction de mesure.

Configuration pour des mesures de tension, de courant continu ou de résistance

Cette partie explique comment configurer le multimètre pour effectuer des mesures de tension continue, de courant continu ou de résistance 2 ou 4-fils.

Tension continue

Le multimètre dispose de cinq gammes de tensions continues. Le [tableau 3-4](#) montre chacune de ces gammes avec sa lecture pleine échelle (qui indique en même temps le nombre de chiffres maximal pour chaque gamme). Le [tableau 3-4](#) montre également la résolution maximale et la résistance d'entrée de chaque gamme. (La résolution est déterminée par le temps d'intégration spécifié; pour plus de détails à ce sujet, voir [Spécification du temps d'intégration](#) plus loin dans ce chapitre). La [figure 3-1](#) illustre les connexions des bornes frontales pour les divers types de mesure de tension. Dans les modes de mise sous tension/PRESET NORM, les mesures de tension sont sélectionnées par défaut. Vous pouvez également spécifier des mesures de tension continue à l'aide de la commande DCV. Par exemple, pour spécifier des mesures de tension continue sur la gamme de 1 V, envoyez:

OUTPUT 722;"DCV 1"

Tableau 3-4 Gammes de tensions continues

Gamme	Lecture pleine échelle	Résolution maximale	Impédance d'entrée
100 mV	120,00000 mV	10 nV	>10 GΩ ^[a]
1 V	1,20000000 V	10 nV	>10 GΩ ^[a]
10 V	12,0000000 V	100 nV	>10 GΩ ^[a]
100 V	120,000000 V	1 µV	10 MΩ
1000 V	1050,00000 V	10 µV	10 MΩ

[a] Avec FIXEDZ OFF. Lorsque la fonction FIXEDZ est active (ON), l'impédance d'entrée est fixée à 10 MΩ. Pour plus de détails à ce sujet, voir [Impédance d'entrée fixe](#), plus loin dans ce chapitre.

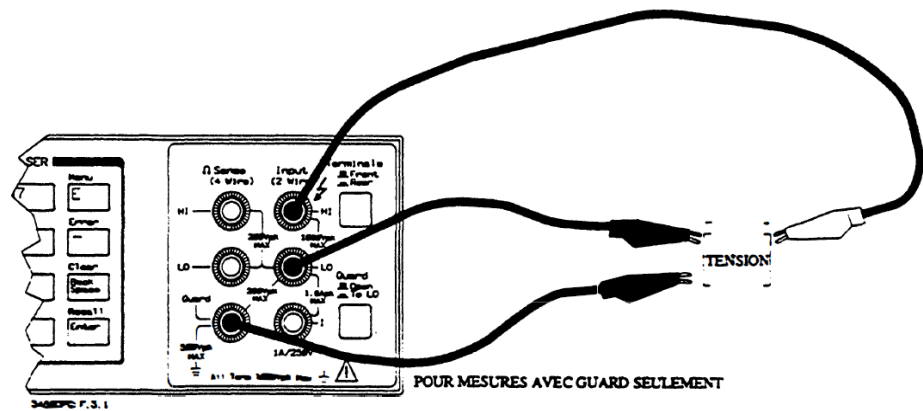


Figure 3-1 Connexions de mesure de tension

Courant continu

Le multimètre mesure les courants en plaçant une résistance de dérivation interne en parallèle avec les bornes d'entrée, en mesurant la tension induite aux bornes de la résistance, après quoi il calcule le courant en fonction de l'équation courant = tension/résistance. Les bornes de courant avant et arrière du multimètre sont protégées par des fusibles de 1 A, 250 V. La [figure 3-2](#) illustre les connexions des bornes frontales pour les divers types de mesure de courant.

Le multimètre dispose de huit gammes de courants continus. Le [tableau 3-5](#) montre chacune de ces gammes avec sa lecture pleine échelle (qui indique en même temps le nombre de chiffres maximal pour chaque gamme). Le [tableau 3-5](#) montre également la résolution maximale et la résistance de dérivation de chaque gamme. (La résolution est déterminée par le temps d'intégration spécifié; pour plus de détails à ce sujet, voir [Spécification du temps d'intégration](#) plus loin dans ce chapitre). Vous pouvez également spécifier des mesures de courant continu à l'aide de la commande DCI. Par exemple, pour spécifier des mesures de courant continu sur la gamme de

10 μ A, envoyez:

`OUTPUT 722;"DCI 10E-6"`

Tableau 3-5 Gammes de courants continus

Gamme	Lecture pleine échelle	Résolution maximale	Résistance de dérivation
100 nA	120,000 nA	1 pA	545.2 k Ω
1 μ A	1,200000 μ A	1 pA	45.2 k Ω
10 μ A	12,000000 μ A	1 pA	5.2 k Ω
100 μ A	120,00000 μ A	10 pA	730 Ω
1 mA	1,2000000 mA	100 pA	100 Ω
10 mA	12,000000 mA	1 nA	10 Ω
100 mA	120,00000 mA	10 nA	1 Ω
1 A	1,0500000 A	100 nA	0,1 Ω

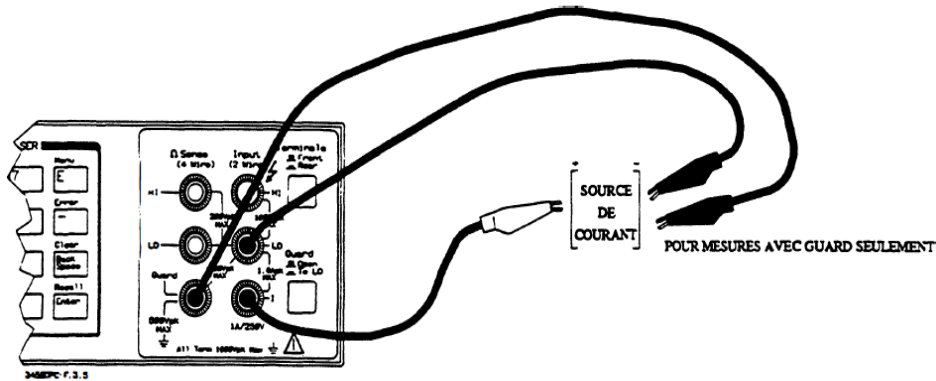


Figure 3-2 Connexions de mesure de courant

Résistance

Le multimètre mesure une résistance en lui appliquant un courant connu. Le courant passant à travers la résistance génère une tension. Le Keysight 3458A mesure cette tension et calcule la résistance inconnue (résistance = tension/courant). Le [tableau 3-6](#) montre les gammes de résistance 2 et 4-fils avec leur lecture pleine échelle (qui indique en même temps le nombre de chiffres maximal pour chaque gamme). Le [tableau 3-6](#) montre également la résolution maximale et le courant appliqué pour chaque gamme. (La résolution est déterminée par le temps d'intégration spécifié; pour plus de détails à ce sujet, voir [Spécification du temps d'intégration](#) plus loin dans ce chapitre).

Tableau 3-6 Gammes de résistances

Gamme	Lecture pleine échelle	Résolution maximale	Courant appliqué
10 Ω	12,00000 Ω	10 $\mu\Omega$	10 mA
100 Ω	120,00000 Ω	10 $\mu\Omega$	1 mA
1 k Ω	1,2000000 k Ω	100 $\mu\Omega$	1 mA
10 k Ω	12,000000 k Ω	1 m Ω	100 μ A
100 k Ω	120,00000 k Ω	10 m Ω	50 μ A
1 M Ω	1,2000000 M Ω	100 m Ω	5 μ A
10 M Ω	12,000000 M Ω	1 Ω	500 nA
100 M Ω	120,00000 M Ω	10 Ω	500 nA
1 G Ω	1,2000000 G Ω	100 Ω	500 nA

Résistance 2-fils

Les mesures de résistance 2-fils sont utilisées quand la résistance des fils de liaison est très petite devant la valeur mesurée. Si la résistance de test est importante par rapport à celle de la mesure souhaitée, la valeur obtenue ne sera pas précise. Si par exemple vous mesurez une résistance d'un ohm située à trois mètres. Si vous utilisez du fil de cuivre normal pour effectuer les connexions, les 6 mètres de fils ajoutent environ 0,5 ohm à la mesure. Ce qui donne une mesure totale de 1,5 ohm, soit une erreur de 50%. D'autres facteurs peuvent contribuer à augmenter la résistance des fils de liaison; par exemple des connexions de

mauvaise qualité, des fils endommagés, ou une très haute température. Vous pouvez améliorer la précision des mesures de résistance 2-fils en utilisant la fonction mathématique NULL. (pour plus de détails sur la fonction **NULL** voir chapitre 4). La **figure 3-3** illustre les connexions des bornes frontales pour les mesures de résistance 2-fils. Vous pouvez également spécifier des mesures de résistance 2-fils à l'aide de la commande OHM. Par exemple, pour spécifier des mesures de résistance 2-fils sur la gamme de 1 k Ω , envoyez:

OUTPUT 722; "OHM 1E3"

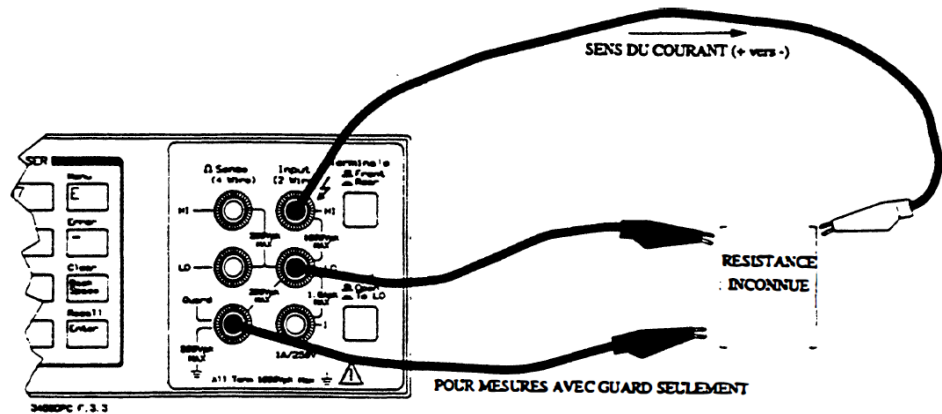


Figure 3-3 Connexions de mesure de résistance 2-fils

Résistance 4-fils

Le mode de mesure 4-fils élimine l'erreur de mesure engendrée par la résistance des fils de liaison. Dans les mesures 2-fils, la mesure de la tension est effectuée sur la résistance combinée des câbles de liaison et de la résistance inconnue. Dans les mesures 4-fils, la tension n'est mesurée que sur la résistance inconnue, non sur la somme des deux. Le mode 4-fils est essentiel pour une excellente précision, surtout si la résistance des câbles de liaison est élevée par rapport à la résistance mesurée. La **figure 3-4** illustre les connexions des bornes frontales pour les mesures de résistance 4-fils. Vous pouvez également spécifier des mesures de résistance 4-fils à l'aide de la commande OHMF. Par exemple, pour spécifier des mesures de résistance 4-fils sur la gamme de 10 M Ω , envoyez:

OUTPUT 722; "OHMF 10E6"

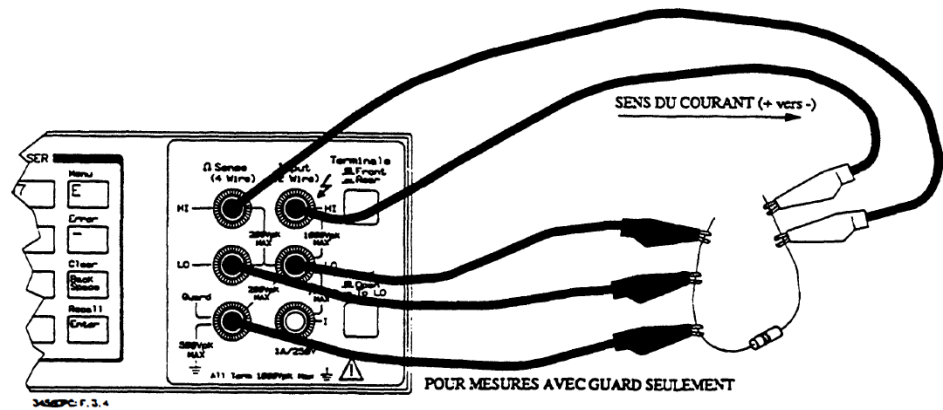


Figure 3-4 Connexions de mesure de résistance 4-fils

Configuration du convertisseur A/N (analogique/ numérique)

La configuration du convertisseur A/N détermine la vitesse de mesure, la résolution, la précision et la réjection de mode normal^[1] pour les mesures de résistance ou CC. La fréquence de référence, le temps d'intégration spécifié et la résolution demandé affectent la configuration du convertisseur A/N.

Fréquence de référence

Lorsqu'il est sous tension, le Keysight 3458A mesure la fréquence secteur, arrondit sa valeur à 50 ou 60 Hz et utilise cette valeur comme fréquence de référence du convertisseur A/N. (Pour une fréquence secteur de 400 Hz, le multimètre utilise 50 Hz - sous-harmonique de 400 Hz - comme fréquence de référence). Pour les mesures de résistance ou cc, le multimètre élimine les bruits de mode normal à la fréquence de référence lorsque le temps d'intégration est ≥ 1 période secteur. Pour plus de détails à ce sujet, voir **Spécification du temps d'intégration** (ci-après).

[1] La réjection de mode normal (NMR) est la capacité du multimètre à rejeter (éliminer) les bruits à la fréquence secteur à partir des mesures CC ou de résistance.

Modification de la fréquence de référence Dans la plupart des cas, la fréquence de référence de mise sous tension offre un excellent taux de réjection en mode normal. Si toutefois vous désirez obtenir une réjection maximale, vous devez définir la fréquence de référence à la fréquence secteur exacte. (Si votre fréquence secteur est sujette à dérivation, vous devez périodiquement corriger la fréquence de référence). La commande suivante mesure la fréquence secteur et définit la fréquence de référence à la valeur mesurée exacte (pour une fréquence secteur de 400 Hz, le multimètre divise la fréquence mesurée par 8 et utilise cette valeur comme fréquence de référence).

OUTPUT 722; "LFREQ LINE"

Vous pouvez également utiliser la commande LFREQ pour spécifier directement la fréquence de référence. Cette fonction est particulièrement utile lorsque le multimètre a une fréquence secteur différente de celle de l'instrument qu'il mesure. Supposons par exemple que le Keysight 3458A ait une fréquence secteur de 60 Hz et que l'appareil qu'il mesure dépende de 50 Hz. Pour obtenir une réjection de mode normal dans ce cas, il suffit de spécifier la fréquence de référence à 50 Hz comme suit:

OUTPUT 722; "LFREQ 50"

N'oubliez pas que si le multimètre est mis hors puis sous tension, ou qu'il est réinitialisé à l'aide de la touche **Reset** du panneau avant, il reprendra la valeur arrondie de 50 ou 60 Hz comme fréquence de référence.

Spécification du temps d'intégration On appelle "temps d'intégration" la durée pendant laquelle le convertisseur A/N mesure le signal d'entrée. Dans les mesures CC ou de résistance, le temps d'intégration détermine la vitesse de mesure, la précision, le nombre maximal de chiffres (résolution) et le taux de réjection des bruits en mode normal à la fréquence de référence du convertisseur NN. Vous pouvez spécifier le temps d'intégration en nombre de périodes secteur à l'aide de la commande NPLC ou directement (en secondes) à l'aide de la commande APER. Comme les commandes NPLC et APER définissent toutes deux le temps d'intégration, l'exécution de l'une annule automatiquement le temps d'intégration précédemment établi par l'autre.

Spécification du nombre de périodes secteur Le multimètre élimine les bruits à la fréquence de référence du convertisseur NN lorsque le temps d'intégration est ≥ 1 période secteur. Vous pouvez spécifier le temps d'intégration en nombre de périodes secteur à l'aide de la commande NPLC. Le multimètre multiplie le nombre de périodes secteur (PLC) spécifiés par la période de la fréquence de

référence du convertisseur NN (commande LFREQ) pour déterminer le temps d'intégration. Par exemple, la période d'une alimentation secteur 50 Hz est $1/50 = 20$ ms. Si vous spécifiez 10 PLC, le temps d'intégration sera de 200 ms. Dans l'état de mise sous tension, le temps d'intégration est à 10 PLC par défaut. Dans l'état de préconfiguration (PRESET NORM), il est à 1 PLC. Pour définir le temps d'intégration des mesures les plus rapides (avec la plus basse précision, la plus basse résolution et sans NMR), envoyez:

OUTPUT 722; "NPLC 0"

Pour spécifier la plus haute précision, la plus haute résolution et une réjection de mode normal (NMR) de 80 dB pour les mesures CC ou de résistance (avec la vitesse de mesure la plus basse), envoyez:

OUTPUT 722;"NPLC 1000"

Vous pouvez spécifier les périodes secteur dans les gammes suivantes:

**0-1 PLC par incréments de 0,000006 PLC (fréquence de référence 60 Hz)
ou 0,000005 PLC (fréquence de référence 50 Hz)**

1-10 PLC par incréments de 1 PLC

10-1000 PLC par incréments de 10 PLC

REMARQUE

Pour les temps d'intégration supérieurs à 10 PLC, le multimètre établit une moyenne sur un certain nombre de lectures en utilisant un temps d'intégration de 10 PLC. Si vous spécifiez 40 PLC par exemple, le multimètre établira une moyenne sur quatre lectures de 10 PLC.

La vaste gamme de périodes secteur proposées offre une grande souplesse pour le choix de la vitesse de mesure, de la précision, de la résolution et de la réjection de mode normal. Typiquement, vous choisirez un temps d'intégration correspondant à la vitesse de mesure souhaitée tout en conservant une résolution et une réjection de mode normal acceptables. Les tableaux de spécification figurant en **annexe A** montre les relations entre le temps d'intégration, le nombre de chiffres affichés (résolution) et la réjection de mode normal pour les mesures CC et de résistance.

Spécification directe du temps d'intégration Pour les mesures CC et de résistance, vous pouvez directement spécifier le temps d'intégration (en

secondes) à l'aide de la commande APER (ouverture). Par exemple, pour spécifier un temps d'intégration de 22 ms, envoyez:

OUTPUT 722;"APER.022"

Avec la commande APER, vous pouvez spécifier des temps d'intégration qui varient de 500 ns à 1 s par incréments de 100 ns. Cette commande est surtout utilisée pour l'échantillonnage d'une portion spécifique du signal (une impulsion par exemple) ou pour la numérisation. Vous pouvez également l'utiliser pour éliminer un signal de bruit d'une fréquence spécifique du signal d'entrée. Dans ce cas, le temps d'intégration doit être un multiple entier de la période du signal à rejeter. Par exemple, pour éliminer les bruits avec une fréquence de 100 Hz (période = 10 ms), vous pouvez définir le temps d'intégration à 10 ms, 20 ms, 30 ms, etc.

Spécification de la résolution

Vous pouvez spécifier la résolution de la mesure comme dernier paramètre d'une commande de fonction (FUNC, ACV, DCV, etc.) ou de la commande RANGE^[1]. Ce paramètre est appelé *%_resolution* puisqu'en fait, vous spécifiez un pourcentage du paramètre *max_input*. (Plus plus de détails sur le paramètre *max_input* (entrée max.), se reporter au paragraphe [Spécification de la gamme](#) plus haut dans ce chapitre). Le multimètre multiplie le paramètre *%_resolution* spécifié par *max_input* pour déterminer la résolution de la mesure. Pour calculer le paramètre *%_resolution*, utilisez l'équation:

$$\%\_resolution = (\text{résolution réelle} / \text{entrée maximale}) \times 100$$

Par exemple, supposons que l'entrée maximale attendue soit de 10 V cc et que vous vouliez une résolution de 1 mV cc, l'équation équivaudra à:

$$\%\_resolution = (0,001/10) \times 100 = 0,01$$

Si vous utilisez la valeur par défaut du paramètre *%_resolution*, le temps d'intégration sera celui spécifié par la dernière commande APER ou NPLC.

Pour les mesures CC ou de résistance (et les mesures alternatives analogiques), la résolution est déterminée par le temps d'intégration du convertisseur NN. En spécifiant une résolution, vous spécifiez indirectement un temps d'intégration. Comme la commande APER ou NPLC spécifie également un temps d'intégration, il apparaît un problème de priorité que le Keysight 3458A résout comme suit:

[1] Vous pouvez également spécifier la résolution à l'aide de la commande RES. Pour plus de détails à ce sujet, voir [chapitre 6](#).

- Si vous envoyez la commande APER ou NPLC *avant* de spécifier la résolution, le multimètre prend la commande correspondant à la plus haute résolution (ou le plus grand temps d'intégration).
- Si vous envoyez la commande APER ou NPLC *après* avoir spécifié la résolution, le multimètre utilise le temps d'intégration indiqué par la commande APER ou NPLC et toute résolution spécifiée précédemment est ignorée.

Quand faut-il spécifier la résolution Pour les mesures CC ou de résistance, il est conseillé de spécifier la résolution lorsque celle fournie par la commande NPLC ou APER est insuffisante. Dans le programme suivant par exemple, la ligne 10 spécifie 1 PLC de temps d'intégration, ce qui correspond à une réjection en mode normal de 60 dB et à une résolution de 7,5 chiffres. C'est-à-dire une résolution réelle de 1 µV sur la gamme 10 V. Cette application requiert une résolution de 100 nV avec une entrée maximale de 10 V. L'équation précédente donne un paramètre `%_resolution` de 0,000001 (IE-6), comme indiqué à la ligne 20.

```
10 OUTPUT 722;"NPLC 1"
20 OUTPUT 722;"DCV 10, 1E-6"
30 END
```

Auto-zéro

La fonction d'auto-zéro permet de s'assurer que les éventuelles erreurs de décalage internes au Keysight 3458A n'affectent pas les mesures suivantes CC ou de résistance. Cette fonction est contrôlée par la commande AZERO. Lorsqu'elle est active (AZERO ON), le multimètre déconnecte de manière interne le signal d'entrée et effectue une lecture de zéro après chaque mesure. Il soustrait ensuite la lecture de zéro de la mesure précédente. Lorsque la fonction AZERO est à OFF ou ONCE, le multimètre effectue une lecture de zéro et la soustrait de toutes les mesures suivantes. Dès que vous avez exécuté la commande AZERO OFF ou ONCE, le multimètre prend la mesure d'auto-zéro lorsque le premier événement d'armement de déclenchement survient pour tous les événements excepté TARM EXT qui génère une mesure d'auto-zéro lorsque la commande TARM EXT est exécutée. La mesure d'auto-zéro est ensuite réactualisée après chaque changement de fonction, de gamme ou de temps d'intégration (cette mise à jour s'effectue lorsque l'événement d'armement de déclenchement survient ou que la commande TARM EXT est exécutée). Dans les états de mise sous tension/PRESET NORM, la fonction d'auto-zéro est active (ON). Vous pouvez l'invalider en envoyant:

OUTPUT 722;"AZERO OFF"

REMARQUE

Il est conseillé de conserver la fonction d'auto-zéro (commande AZERO ON) pour les mesures de résistance 4-fils. Si vous devez invalider la fonction d'auto-zéro (AZERO OFF ou ONCE), n'oubliez pas d'effectuer toutes les connexions de mesure avant et de vous assurer que la résistance des fils ne changera pas. Si vous invalidez la fonction d'auto-zéro avant d'effectuer les connexions de résistance 4-fils ou si la résistance des fils varie (cas des balayages), vos mesures de résistance 4-fils risquent d'être inexactes.

Compensation de décalage

Comme la mesure d'une résistance implique la mesure de la tension induite à ses bornes, toute tension externe présente (tension de décalage) affectera la précision de la mesure. Lorsque la fonction de compensation de décalage est active, le multimètre corrige les mesures de résistance en supprimant les effets de la tension de décalage. Pour ce faire, il mesure d'abord la tension d'entrée pendant que le courant est appliqué. La source de courant est ensuite invalidée et il remesure la tension d'entrée. La tension induite correspond à la différence entre les deux tensions mesurées. Vous pouvez utiliser la compensation de décalage à la fois pour les mesures de résistance 2-fils et 4-fils. Le multimètre ne peut compenser les tensions parasites que dans l'intervalle 10 Ω -100 k Ω ; la compensation de décalage ne fonctionne pas dans les gammes supérieures. Dans les états de mise sous tension/PRESET NORM, la compensation de décalage est invalidée. Pour l'activer, envoyez:

OUTPUT 722:"OCOMP ON"

Les tensions de décalage maximales des mesures de résistance avec compensation de décalage sont indiquées dans l'[annexe A](#).

Impédance d'entrée fixe

Quand vous effectuez des mesures de tension continue, vous pouvez fixer l'impédance d'entrée du Keysight 3458A avec la commande FIXEDZ. Cette fonction est utile pour éviter qu'un changement d'impédance d'entrée (provoqué par un changement de gamme) n'affecte la mesure. Le [tableau 3-4](#) indique les impédances d'entrée lorsque FIXEDZ est invalidé (OFF). Lorsque la fonction FIXEDZ est active (ON), l'impédance d'entrée est constante (10 MO) pour

toutes les gammes de tensions continues. Dans les états de mise sous tension/ PRESET NORM, l'impédance d'entrée fixe est invalidée (OFF). Pour l'activer, envoyez:

OUTPUT 722; "FIXEDZ ON"

Pour l'invalider, envoyez:

OUTPUT 722;"FIXEDZ OFF"

Configuration pour les mesures alternatives

Cette partie explique comment configurer le multimètre pour effectuer des mesures de tension alternative, ou alternative + continue, des mesures de courant alternatif ou alternatif + continu, des mesures de fréquence et de période.

Tension alternative ou alternative + continue

Le multimètre peut mesurer une tension alternative ou une tension alternative + continue en valeur efficace (RMS) vraie à l'aide de l'une des trois méthodes suivantes: conversion Eff. analogique, conversion d'échantillons aléatoires ou conversion d'échantillons synchrones. Chaque méthode de mesure a six gammes: 10 mV, 100 mV, 1 V, 10V, 100 V et 1000 V avec une résolution maximale de 6,5 chiffres pour chaque gamme.

Le [tableau 3-7](#) indique les caractéristiques de mesure et le signal requis pour chaque méthode de mesure. La [figure 3-1](#) illustre les connexions des bornes frontales pour les différents types de mesures de tension.

Lorsqu'il mesure une tension alternative, le multimètre ne mesure que la composante alternative du signal d'entrée. Lorsqu'il mesure une tension alternative + continue, le multimètre mesure la composante continue et la composante alternative dans les gammes de fréquences indiquées au [tableau 3-7](#). Vous remarquerez que lorsque vous mesurez une tension alternative + continue à l'aide de la méthode analogique, par exemple, les composantes alternatives au-dessous de 10 Hz ne sont pas incluses dans la mesure.

REMARQUE

Quand vous effectuez des mesures dans les gammes 10 mV et 100 mV, quelle que soit la méthode de mesure utilisée, il est possible que des bruits (transitoires générés lors de la mise en route ou l'arrêt de gros moteurs) interfèrent avec les mesures et entraînent des lectures imprécises. Pour des mesures précises sur ces gammes, assurez-vous que l'environnement immédiat est électriquement "calme" et utilisez des cordons de test blindés.

Tableau 3-7 Méthodes de mesure des tensions alternatives et alternatives + continues

Méthode de mesure ACV/ACDCV	Gamme de fréquences	Précision maximale	Signal répétitif requis	Lectures par seconde	
				Min.	Max.
Synchrone	1 Hz - 10 MHz	0,01%	Oui	0,025	10
Analogique	10 Hz - 2 MHz	0,03%	Non	0,8	50
Aléatoire	20 Hz - 10 MHz	0,10%	Non	0,025	45

Conversion d'échantillons synchrones

La conversion d'échantillons synchrones calcule la valeur efficace vraie à partir d'échantillons; cette méthode exige que le signal d'entrée soit répétitif (périodique). L'échantillonnage synchrone fournit une excellente linéarité et reste la plus précise des trois méthodes. On l'utilise surtout pour mesurer des signaux périodiques dans la gamme de fréquences de 1 Hz à 10 MHz.

Remarques à propos de l'échantillonnage synchrone

- En mode d'échantillonnage synchrone, le multimètre utilise l'événement LEVEL (par défaut) pour synchroniser l'échantillonnage sur le signal d'entrée. Si celui-ci est supprimé pendant une lecture et n'est pas rappliqué au bout d'un certain laps de temps (déterminé principalement par la largeur de bande alternative - expliquée plus loin dans ce chapitre), la méthode de mesure change au profit de l'échantillonnage aléatoire afin que la mesure puisse être effectuée. Vous pouvez empêcher ce changement de méthode à l'aide d'une commande SSRC. Vous pouvez également synchroniser l'échantillonnage synchrone sur un signal appliqué sur le connecteur **Ext Trig** (Déclenchement externe) à l'aide de la commande SSRC. Pour plus de détails sur cette commande et son utilisation, se reporter au [chapitre 6](#).
- Lorsque vous utilisez la source de synchronisation LEVEL, il est possible que le bruit présent sur le signal d'entrée provoque de faux déclenchements de niveau et occasionne par là même des lectures inexactes. Pour obtenir des mesures précises, assurez-vous que l'environnement immédiat est électriquement "calme" et utilisez des cordons de test blindés. La validation du filtre de niveau (commande LFIL.TER ON) réduit la sensibilité à ce bruit. Pour plus de détails sur cette commande, se reporter au [chapitre 6](#).

- Le signal d'entrée est toujours couplé en courant continu pour un échantillonnage synchrone, quelle que soit la fonction de mesure (ACV ou ACDCV) spécifiée. Lorsque ACV est spécifié, les composantes de courant continu sont mathématiquement soustraites de la lecture. Ce point est important puisque les niveaux de tension alternative et continue une fois combinés peuvent être à l'origine d'une condition de surcharge qui ne se serait normalement pas produite en présence de la seule tension alternative.

Conversion analogique de la valeur efficace

La conversion analogique de la valeur efficace intègre directement le signal d'entrée et c'est la méthode de mesure sélectionnée par défaut à la mise sous tension du multimètre. Cette méthode convient parfaitement pour mesurer des signaux dans la gamme de fréquences de 10 Hz à 2 MHz et s'avère être la méthode de mesure la plus rapide des trois.

Conversion d'échantillons aléatoires

A chaque lecture, la méthode de conversion d'échantillons aléatoires prend de nombreux échantillons du signal d'entrée. Les échantillons sont espacés aléatoirement par la base de temps interne et la valeur efficace vraie du signal est calculée statistiquement. L'échantillonnage aléatoire ne requiert pas un signal d'entrée répétitif (comme l'échantillonnage synchrone); cette méthode convient donc pour mesurer les signaux bruyants à bande large. Elle offre une excellente linéarité, une bonne précision et convient tout particulièrement aux mesures de bas niveau (<1/10 de la pleine échelle). Avec l'échantillonnage aléatoire, la largeur de bande de la mesure peut varier de 20 Hz à 10 MHz.

Spécification de la méthode de mesure de la tension alternative

A la mise sous tension, le multimètre sélectionne la conversion analogique de la valeur efficace. Dans l'état de mise sous tension, il suffit donc de sélectionner les mesures de tension alternative ou alternative + continue comme suit:

```
OUTPUT 722;"ACV"      !SELECTIONNE LES MESURES DE TENSION CA, COUPLEE CA
ou
OUTPUT 722;"ACDCV"    !SELECTIONNE LES MESURES DE TENSION CA, COUPLEE CC
```


La commande SET ACY vous permet de spécifier la méthode de mesure de la tension alternative. Par exemple, pour spécifier l'échantillonnage aléatoire, envoyez:

OUTPUT 722;"SETACV RNDM"

Pour sélectionner l'échantillonnage synchrone, envoyez:

OUTPUT 722;"SETACV SYNC"

Pour revenir à la conversion analogique de la valeur efficace, envoyez:

OUTPUT 722;"SETACV ANA"

La méthode de mesure sélectionnée reste active (1) tant que l'instrument n'est pas mis hors tension, (2) tant qu'il n'est pas réinitialisé ou (3) tant qu'une autre méthode n'est pas spécifiée. A chaque fois que vous sélectionnez des mesures de tension alternative ou alternative + continue, la dernière méthode spécifiée (ou la méthode par défaut de la mise sous tension) sera utilisée.

Courant alternatif ou alternatif + continu

Le multimètre mesure les courants en plaçant une résistance interne en parallèle avec les bornes d'entrée, en mesurant la tension induite aux bornes de la résistance, après quoi il calcule le courant en fonction de l'équation courant = tension/résistance. A la différence des mesures de tension alternative ou alternative + continue, les mesures de courant alternatif ou alternatif + continu peuvent être effectuées uniquement à l'aide de la méthode analogique (intégration directe du signal d'entrée). Les bornes de courant avant et arrière du multimètre sont protégées par des fusibles de 1A, 250V. La [figure 3-2](#) illustre les connexions des bornes frontales pour les divers types de mesure de courant.

Le multimètre dispose de cinq gammes de courants alternatifs ou alternatifs + continus. Lorsqu'il mesure un courant alternatif, le multimètre ne mesure que la composante alternative du signal d'entrée. Lorsqu'il mesure un courant alternatif + continu, le multimètre mesure la composante continue et la composante alternative dont les fréquences sont > 10 Hz. Vous remarquerez que lorsque vous mesurez un courant alternatif + continu, les composantes alternatives au-dessous de 10 Hz ne sont pas incluses dans la mesure. La résolution maximale des mesures de courant alternatif ou alternatif+ continu est de 6,5 chiffres. Le [tableau 3-8](#) montre chaque gamme avec sa lecture pleine échelle, la résolution maximale et la résistance de dérivation de chaque gamme. (La résolution est-déterminée par le temps d'intégration spécifié; pour plus de détails à ce sujet, voir [Spécification du temps d'intégration](#), plus loin dans ce chapitre). Vous pouvez

également spécifier des mesures de courant alternatif à l'aide de la commande ACI ou des mesures de courant alternatif+ continu à l'aide de la commande ACDCI. Par exemple, pour spécifier des mesures de courant alternatif dans la gamme 100 μ A, envoyez:

OUTPUT 722;"ACI 100E-6"

Pour spécifier des mesures de courant alternatif + continu dans la gamme 10 mA, envoyez:

OUTPUT 722;"ACDCI 10E-3"

Tableau 3-8 Gammes de courants alternatifs et alternatifs+ continus et résolution

Gamme	Lecture pleine échelle	Résolution maximale	Résistance de dérivation
100 μ A	120,0000 μ A	100 pA	730 Ω
1 mA	1,200000 mA	1 nA	100 Ω
10 mA	12,000000 mA	10 nA	10 Ω
100 mA	120,0000 mA	100 nA	1 Ω
1 A	1,050000 A	1 μ A	0,1 Ω

Fréquence ou période

Le compteur de fréquence et de période du Keysight 3458A accepte en entrée des tensions alternatives ou des courants alternatifs. La résolution maximale est de 7 chiffres^[1] pour les mesures de fréquence et/ou de période. (Pour plus de détails à ce sujet, voir [Spécification de la résolution](#), plus loin dans ce chapitre).

Vous spécifiez les mesures de fréquence à l'aide de la commande FREQ ou les mesures de période à l'aide de la commande PER. Pour les mesures de fréquence ou de période, vous devez également spécifier le type de signal d'entrée (tension ou courant) et si les mesures seront couplées en courant alternatif ou continu. Vous utiliserez pour ce faire la commande FSOURCE (la valeur de mise sous tension/par défaut est ACV). Le [tableau 3-9](#) montre les paramètres de la commande FSOURCE, le type d'entrée spécifié par chacun d'eux et leur possibilité de mesure respective. Les connexions pour les mesures de fréquence ou de

[1] Le chiffre le plus à gauche, qui correspond à un ½ chiffre dans la plupart des fonctions de mesure, est un chiffre plein (0-9) pour les mesures de fréquence et de période.

période à partir d'une source de tension sont illustrées à la [figure 3-1](#). Les connexions pour les mesures de fréquence ou de période à partir d'une source de courant sont illustrées à la [figure 3-1](#).

Tableau 3-9 Paramètres de la commande FSOURCE

Paramètre FSOURCE	Définition	Possibilités de mesure	
		Fréquence	Période
ACV	Entrée d'une tension ca, couplée ca	1 Hz – 10 MHz	100 ns – 1 s
ACDCV	Entrée d'une tension ca, couplée cc	1 Hz – 10 MHz	100 ns – 1 s
ACI	Entrée d'un courant ca, couplé ca	1 Hz – 100 kHz	10 µs – 1 s
ACDCI	Entrée d'un courant ca, couplé cc	1 Hz – 100 kHz	10 µs – 1 s

Le programme suivant configure le multimètre pour des mesures de fréquence dans la gamme 10 V à partir d'une source de tension. Le signal d'entrée est couplé en courant alternatif.

```
10 OUTPUT 722;"FREQ 10"  
20 OUTPUT 722;"FSOURCE ACV"  
30 END
```

Le programme suivant configure le multimètre pour des mesures de période dans la gamme 10 mA à partir d'une source de courant. Le signal d'entrée est couplé en courant continu.

```
10 OUTPUT 722;"PER 10E-3"  
20 OUTPUT 722;"FSOURCE ACDCI"  
30 END
```

REMARQUE

Pour les mesures de fréquence ou de période, vous pouvez réduire le bruit des signaux haute fréquence au-dessus de 75 kHz en validant le filtre de niveau. Pour plus de détails à ce sujet, voir commande LFILTER dans le [chapitre 6](#).

Spécification de la largeur de bande

La commande ACBAND permet de spécifier les composantes de fréquence du signal d'entrée pour toutes les mesures ca ou ca + cc. Vous permettez ainsi au

multimètre de procéder à des mesures précises et de se configurer pour des mesures les plus rapides possibles. Le premier paramètre de la commande ACBAND spécifie la composante de fréquence la plus basse attendue (la valeur de mise sous tension/PRESET NORM est à 20 Hz). Le second paramètre spécifie la composante de fréquence la plus haute attendue (la valeur de mise sous tension/PRESET NORM est à 2 MHz). Supposons par exemple que la gamme de fréquences du signal d'entrée varie entre 750 Hz et 2 kHz; dans ce cas, vous envoyez:

OUTPUT 722;"ACBAND 750,2000"

La précision (et la vitesse de lecture des mesures ca analogiques) en fonction des composantes de fréquence du signal d'entrée figurent dans l'**"annexe A : Spécifications"** à la page 411 du présent manuel.

REMARQUE

Dans les mesures de tension alternative ou alternative + continue synchrones, les paramètres de largeur de bande sont utilisés par le multimètre pour le calcul des valeurs de temporisation et des paramètres d'échantillonnage. Pour les mesures de fréquence ou de période à gamme automatique, les paramètres de largeur de bande servent à déterminer le laps de temps nécessaire d'établissement de la gamme automatique. Pour toutes ces mesures, il est indispensable que la largeur de bande spécifiée (en particulier la fréquence basse) corresponde aux composantes de fréquences du signal d'entrée.

Spécification du temps d'intégration

On appelle "temps d'intégration" la durée pendant laquelle le convertisseur A/N mesure le signal d'entrée. Dans les mesures CA analogiques, le temps d'intégration détermine le nombre maximal de chiffres de la résolution et suivant la largeur de bande spécifiée, il affecte la vitesse et la précision de la mesure. Les mesures CA analogiques correspondent à des mesures de tension alternative ou alternative + continue effectuées uniquement à l'aide de la méthode de conversion analogique (commande SETACV ANA) et à des mesures de courant alternatif ou alternatif+ continu. Plus les temps d'intégration sont longs, et plus la résolution et la précision des mesure sont élevées, mais plus la vitesse de mesure décroît.

REMARQUE

Le temps d'intégration n'influe pas sur les mesures de fréquence ou de période. Pour les mesures de tension alternative échantillonnées (commande SEIACV SYNC ou SETACV RNDM), le temps d'intégration du convertisseur A/N est choisi automatiquement et le multimètre fournit la résolution spécifiée (voir **Spécification de la résolution** ci-après) en faisant varier le nombre d'échantillons.

Pour les mesures CA analogiques, vous pouvez spécifier le temps d'intégration en nombre de périodes secteur à l'aide de la commande NPLC. (Vous pouvez également utiliser la commande APER pour spécifier le temps d'intégration bien que cette commande soit avant tout spécifique aux mesures continues. Pour plus de détails sur la commande APER, se reporter au **chapitre 6**.) Le multimètre multiplie le nombre de périodes secteur (PLC) spécifiés par la période de la fréquence de référence du convertisseur A/N (commande LFREQ) pour déterminer le temps d'intégration. Par exemple, la période d'une alimentation secteur 50 Hz est $1/50 = 20$ ms. Si vous spécifiez 10 PLC, le temps d'intégration sera de 200 ms. Dans l'état de mise sous tension, le temps d'intégration est à 10 PLC par défaut. Dans l'état de préconfiguration (PRESET NORM), il est à 1 PLC. Pour définir le temps d'intégration des mesures les plus rapides (avec la plus basse précision et une résolution de 4,5 chiffres), envoyez:

OUTPUT 722; "NPLC 0"

Pour spécifier la plus haute précision et la plus haute résolution (6,5 chiffres) avec la vitesse de mesure la plus basse, envoyez:

OUTPUT 722; "NPLC 1000"

Vous pouvez spécifier les périodes secteur dans les gammes suivantes:

**0-1 PLC par incréments de 0,000006 PLC (fréquence de référence 60 Hz)
ou 0,000005 PLC (fréquence de référence 50 Hz)**

1-10 PLC par incréments de 1 PLC

10-1000 PLC par incréments de 10 PLC

REMARQUE

Pour les temps d'intégration supérieurs à 10 PLC, le multimètre établit une moyenne sur un certain nombre de lecture utilisant un temps d'intégration de 10 PLC. Si vous spécifiez 40 PLC par exemple, le multimètre établira une moyenne sur quatre lectures de 10 PLC.

Typiquement, vous choisirez un temps d'intégration correspondant à la vitesse de mesure souhaitée tout en conservant une résolution et une précision acceptables. Le **tableau 3-10** les relations entre le temps d'intégration et le nombre de chiffres affichés (résolution) pour les mesures CA analogiques.

Tableau 3-10 Relations entre le convertisseur A/N et les mesures CA analogiques

Nb de chiffres de résolution	Périodes secteur (commande NPLC)	
	LFREQ = 60 Hz	LFREQ = 50 Hz
4,5	0 – 0,000030	0 – 0,000025
5,5	0,000036 – 0,000360	0,000030 – 0,000300
6,5	0,000366 – 1000	0,000305 – 1000

Spécification de la résolution

Vous pouvez spécifier la résolution de la mesure comme dernier paramètre (paramètre *%_resolution*) d'une commande de fonction (FUNC, ACV, ACI, etc.) ou de la commande RANGE.^[1]

Pour toutes les mesures de tension et de courant ca analogiques et échantillonnées, le paramètre *%_resolution* est spécifié comme pourcentage du paramètre *max_input* (entrée max.) de la commande. Le multimètre multiplie le paramètre *%_resolution* spécifié par *max_input* pour déterminer la résolution de la mesure. Pour calculer le paramètre *%_resolution*, utilisez l'équation:

$$\%\_résolution = (\text{résolution réelle} / \text{entrée maximale}) \times 100$$

Par exemple, supposons que l'entrée maximale attendue soit de 10 V ca et que vous vouliez une résolution de 1 m V ca, l'équation équivaudra à:

$$\%\_résolution = (0,001/10) \times 100 = 0,01$$

Pour les mesures CA analogiques, la résolution est déterminée par le temps d'intégration du convertisseur NN. En spécifiant une résolution, vous spécifiez indirectement un temps d'intégration. Comme la commande NPLC spécifie également un temps d'intégration, il apparaît un problème de priorité que le Keysight 3458A résout comme suit:

- Si vous envoyez la commande NPLC avant de spécifier la résolution, le multimètre prend la commande correspondant à la plus haute résolution (ou le plus grand temps d'intégration).

[1] Vous pouvez également spécifier la résolution à l'aide de la commande RES. Pour plus de détails à ce sujet, voir [chapitre 6](#).

- Si vous envoyez la commande NPLC après avoir spécifié la résolution, le multimètre utilise le temps d'intégration indiqué par la commande NPLC et toute résolution spécifiée précédemment est ignorée.

Pour les mesures CA analogiques, si vous utilisez la valeur par défaut du paramètre *%_resolution*, le temps d'intégration sera celui spécifié par la dernière commande NPLC.

Pour les mesures de fréquence et de période, *%_resolution* spécifie le temps de porte et le nombre de chiffres de résolution comme indiqué dans le [tableau 3-11](#). Par exemple, le programme suivant spécifie des mesures de fréquence à partir d'une tension d'entrée dans la gamme 10 V. Le paramètre *%_resolution* de la ligne 20 (0,00001) spécifie un temps de porte de 1 seconde et 7 chiffres de résolution.

```
10 OUTPUT 722; "FSOURCE ACV"
20 OUTPUT 722; "FREQ 10, .00001"
30 END
```

Si vous prenez la valeur par défaut du paramètre *%_resolution* pour les mesures FREQ ou PER, le multimètre définit *%_resolution* à 0,00001, ce qui sélectionne un temps de porte de 1 seconde et 7 chiffres de résolution.

Tableau 3-11 Temps de porte et Résolution des mesures de fréquence/période

Paramètre <i>%_resolution</i>	Temps de porte sélectionné	Résolution (nb de chiffres)
0,00001	1 s	7
0,0001	100 ms	7
0,001	10 ms	6
0,01	1 ms	5
0,1	100 µs	4

Quand faut-il spécifier la résolution

Pour les mesures analogiques ACV ou ACDCV (commande SETACV ANA), ACI et ACDCI, il est conseillé de spécifier la résolution lorsque celle fournie par la commande NPLC est insuffisante. Dans le programme suivant par exemple, la ligne 10 spécifie un temps d'intégration de 0,0001 PLC, ce qui sélectionne une résolution de 5,5 soit une résolution réelle de 100 µV dans la gamme 10 V. Cette application requiert toutefois une résolution de 10 µV avec une entrée maximale

de 10 V. L'équation précédente donne un paramètre *%_résolution* de 0,0001 (1E-4), comme indique à la ligne 30 (pour cette résolution, une lecture prend environ 40 secondes).

```
10 OUTPUT 722;"NPLC .0001"
20 OUTPUT 722;"SETACV ANA"
30 OUTPUT 722;"ACV 10,1E-4"
40 END
```

Pour les mesures échantillonnées ACV ou ACDCV (commande SETACV RNDM ou SYNC), FREQ et PER, la spécification de la résolution est la seule façon de changer la résolution courante. Pour ces mesures, le temps d'intégration est fixe et aucun conflit ne se produit entre la commande NPLC et le paramètre *%_résolution*. Pour les mesures de tension alternative échantillonnées, le multimètre fournit la résolution spécifiée en faisant varier le nombre d'échantillons pris en compte. (Si vous prenez la valeur par défaut du paramètre *%_résolution*, le multimètre définit le paramètre *%_résolution* à 0,01% pour la méthode de conversion synchrone et à 0,4% pour la méthode de conversion aléatoire). Le programme suivant sélectionne les mesures de tension alternative utilisant la conversion d'échantillons aléatoires. La tension d'entrée maximale attendue est de 10 V et la résolution désirée est de 10 mV, ce qui donne un paramètre% résolution de $0,01/10 \times 100 = 0,1$ (100E-3), spécifié à la ligne 20.

```
10 OUTPUT 722;"SETACV SYNC"
20 OUTPUT 722;"ACV 10, .1"
30 END
```

Configuration pour les mesures de rapport

Pour mesurer des rapports, le multimètre mesure mie tension de référence continue appliquée aux bornes **Ω Sense** et une tension appliquée aux bornes **Input**. Il calcule ensuite le rapport sous la forme:

$$\text{Rapport} = \frac{\text{Tension du signal}}{\text{Tension de reference continue}}$$

La tension du signal d'entrée peut être continue, alternative ou alternative + continue. (Pour mie tension alternative ou alternative + continue, les trois méthodes de mesure - ANA, RNDM ou SYNC - peuvent être utilisées). La tension de référence est toujours continue et doit avoir une entrée mesurable maximale de ± 12 V cc. La **figure 3-5** illustre les connexions des bornes frontales pour les mesures de rapport.

REMARQUE

Les bornes **Ω Sense LO** et **Input LO** doivent avoir une référence commune et des tensions qui ne diffèrent pas de plus de 0,2 V.

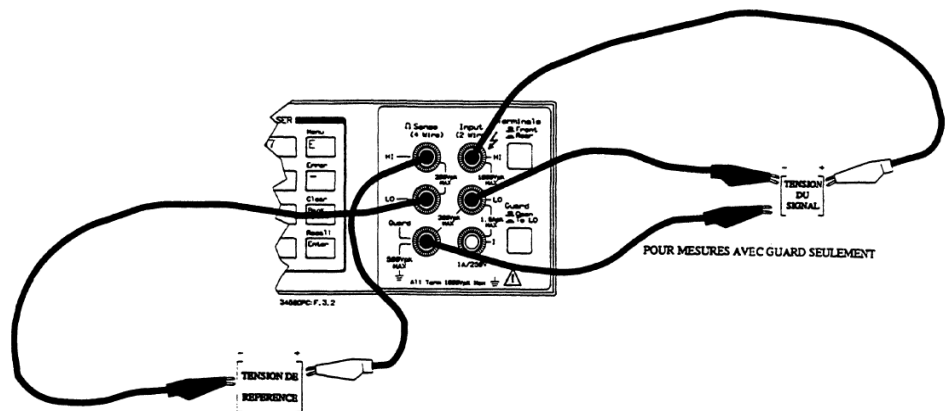


Figure 3-5 Connexions pour les mesures de rapport

Spécification des mesures de rapport

Pour spécifier des mesures de rapport, vous devez d'abord sélectionner la fonction de mesure pour le signal (et la méthode de mesure s'il s'agit d'une mesure de tension alternative ou alternative + continue). et valider ensuite les mesures de rapport à l'aide de la commande **RATIO**. Le programme suivant par exemple spécifie des mesures de rapports sur des tensions alternatives (dans la gamme 10 V) utilisant la conversion d'échantillons synchrones.

```
10 OUTPUT 722;"ACV 10"  
20 OUTPUT 722; "SETACV SYNC"  
30 OUTPUT 722;"RATIO ON"  
40 END
```

Pour invalider les mesures de rapport, envoyez:

```
OUTPUT 722;"RATIO OFF"
```

Pour les mesures de rapport, la gamme de mesure spécifiée ne s'applique qu'à la tension du signal (bornes Input). La gamme utilisée pour mesurer la tension de référence (bornes Ω Sense) est toujours définie automatiquement. Pour plus de détails sur la spécification des gammes, se reporter au début du présent chapitre ([Configuration générale](#)).

Utilisation de la mémoire de sous-programme

Le multimètre peut sauvegarder des chaînes de commandes sous forme de sous-programmes. Cela vous permet d'exécuter des chaînes de commande fréquemment utilisées et de maintenir le temps d'interaction bus/contrôleur au minimum. Comme les sous-programmes sauvegardés sont compilés, le multimètre les exécute beaucoup plus rapidement que les commandes équivalentes transmises par le bus GPIB. Le Keysight 3458A dispose de 14 Ko de mémoire qui se partage entre les sous-programmes et les états (décrits plus loin dans ce chapitre). Lorsque la mémoire qui leur est réservée est pleine, le multimètre génère l'erreur *Memory Error* (bit 7 dans le registre d'erreur).

REMARQUE

Le registre d'état renferme un bit de Sous-programme Terminé qui peut être utilisé pour déterminer la fin de l'exécution d'un sous-programme. Pour plus de détails à ce sujet, voir [Utilisation du registre d'état](#) plus loin dans ce chapitre.

Sauvegarde d'un sous-programme

Pour sauvegarder un sous-programme, vous utilisez les commandes SUB et SUBEND. La commande SUB indique le début du sous-programme et son nom. Le nom d'un sous-programme peut comporter 10 caractères au maximum (caractères alphabétiques ou alphanumériques. Les caractères ? et _ sont également acceptés). Le premier caractère d'un nom alphanumérique doit toujours être alphabétique. Aucun nom de sous-programme (alphabétique ou alphanumérique) ne doit être identique à une commande ou à un paramètre du multimètre ni à un état sauvegardé.

Après la commande SUB, entrez les commandes du sous-programme dans l'ordre où vous voulez qu'elles soient exécutées. Utilisez la commande SUBEND pour indiquer la fin du sous-programme. Tous les sous-programmes sont enregistrés en mémoire permanente (ils ne sont pas effacés à la mise hors tension de l'instrument), à moins que le sous-programme fasse l'objet d'une compression. (Voir [Compression des sous-programmes](#) plus loin dans ce chapitre). Le programme suivant par exemple sauvegarde les lignes 20 à 60 sous forme d'un sous-programme intitulé DCCURI.

```
10 OUTPUT 722;"SUB DCCUR1"
20 OUTPUT 722;"MEM FIFO"
30 OUTPUT 722;"TRIG HOLD"
40 OUTPUT 722;"DCI 1,.01"
```

```
50 OUTPUT 722; "NRDGS 5, AUTO"  
60 OUTPUT 722; "TRIG SGL"  
70 OUTPUT 722; "SUBEND"  
80 END
```

Si vous créez un nouveau sous-programme dont le nom est identique à celui d'un sous-programme déjà existant, le nouveau sous-programme "écrasera" (effacera) l'ancien.

Exécution d'un sous-programme

Pour exécuter un sous-programme préalablement enregistré, envoyez la commande CAU. accompagnée du nom du sous-programme. Par exemple, pour exécuter le précédent sous-programme, envoyez:

```
OUTPUT 722; "CALL DCCUR1"
```

REMARQUE

Lorsque la mémoire-tampon d'entrée (décrite plus loin dans ce chapitre) est invalidée, le multimètre ne libère pas l'interface GPIB tant que le sous-programme n'est pas entièrement exécuté ou tant qu'il ne rencontre pas une instruction PAUSE (décrite ci-après). Pour plus de détails sur la libération du bus immédiatement après l'appel d'un sous-programme, se reporter au paragraphe **Utilisation de la mémoire-tampon d'entrée**, plus loin dans ce chapitre. Pour annuler l'exécution d'un sous-programme, envoyez la commande GPIB "Device Clear" (Libérer appareil).

Vous pouvez visualiser le nom de tous les sous-programmes enregistrés à partir du panneau avant en accédant à la commande CALL et en appuyant sur une touche fléchée (vers le haut ou vers le bas). Dès que le nom du sous-programme recherché s'affiche, appuyez sur **Enter** pour l'exécuter.

Suspension de l'exécution d'un sous-programme

Vous pouvez temporairement suspendre l'exécution d'un sous-programme en lui ajoutant une instruction PAUSE. Le multimètre exécute alors le sous programme, commande par commande. Dès qu'il rencontre la commande PAUSE, il suspend l'exécution du sous-programme et si celui-ci était exécuté depuis un ordinateur distant, il libère le bus GPIB. Le programme suivant par exemple comporte une commande PAUSE à la ligne 60.

```
10 OUTPUT 722; "SUB 2"  
20 OUTPUT 722;"MEM FIFO"  
30 OUTPUT 722;"TRIG HOLD"  
40 OUTPUT 722;"DCV 10"  
50 OUTPUT 722;"NRDGS 5,AUTO"  
60 OUTPUT 722;"PAUSE"  
70 OUTPUT 722;"TRIG SGL"  
80 OUTPUT 722;"SUBEND"  
90 END
```

Lorsque vous appelez le programme ci-dessus, celui-ci s'exécute jusqu'à la commande PAUSE, après quoi il s'interrompt. Pour que l'exécution se poursuive, envoyez:

```
OUTPUT 722;"CONT"
```

L'exécution d'un sous-programme interrompu peut également reprendre à l'aide de la commande GPIB GET (Group Execute Trigger - cette commande ne déclenche pas une lecture mais permet simplement au sous-programme de poursuivre son exécution).

Sous-programmes emboîtés

Un sous-programme peut appeler un autre sous-programme (sous-programmes emboîtés). Par exemple, lorsque le programme suivant est appelé (commande CALL 1), il effectue dix lectures de tension continue puis il appelle le sous-programme précédemment enregistré sous le nom de *DCCUR1*.

```
10 OUTPUT 722; "SUB 1"  
20 OUTPUT 722;"TRIG HOLD"  
30 OUTPUT 722;"NRDGS 10,AUTO"  
40 OUTPUT 722;"DCV 10"  
50 OUTPUT 722;"TRIG SGL"  
60 OUTPUT 722; "CALL DCCUR1"  
70 OUTPUT 722; "SUBEND"  
80 END
```

Un sous-programme comportant une commande PAUSE ne peut pas être appelé par un autre sous-programme. Le multimètre vous permet d'emboîter jusqu'à 10 sous-programmes; c'est-à-dire que le sous-programme 1 appelle le sous-programme 2, qui à son tour appelle le sous-programme 3, qui appelle le sous-programme 4..... qui appelle le sous-programme 10.

Sous-programme d'auto-démarrage

Lorsque vous donnez le nom "0" à un sous-programme, celui-ci s'exécute à chaque fois que le multimètre termine sa séquence de mise sous tension ou qu'il est réinitialisé à l'aide de la touche **Reset** du panneau avant. Cette caractéristique est particulièrement utile pour replacer automatiquement le multimètre à l'état dans lequel il se trouvait avant une coupure secteur par exemple. Dès qu'une coupure secteur est détectée, le multimètre sauvegarde son état dans l'état 0 (les états sont décrits plus loin dans ce chapitre). Le programme suivant sauvegarde un programme d'auto-démarrage qui remplace automatiquement le multimètre à son état de mise sous tension et définit la fréquence de référence du convertisseur A/N à la valeur exacte de la fréquence secteur (pour plus de détails à ce sujet, voir [Modification de la fréquence de référence](#) plus haut dans ce chapitre).

```
10 OUTPUT 722; "SUB 0"  
20 OUTPUT 722;"RSTATE 0"  
30 OUTPUT 722;"LFREQ LINE"  
40 OUTPUT 722; "SUBEND"  
50 END
```

Vous pouvez également appeler le sous-programme d'auto-démarrage (commande CALL 0) si vous devez exécuter le sous-programme sans mettre le multimètre hors puis sous tension.

Compression des sous-programmes

Lorsque vous enregistrez un sous-programme, le multimètre sauvegarde le texte ASCII en mémoire permanente et sa version compilée en mémoire non-permanente. Lorsque vous appelez un sous-programme, le multimètre exécute la version compilée (ce qui explique pourquoi un sous-programme s'exécute plus rapidement que les commandes équivalentes transmises par le bus GPIB). Lorsque l'appareil est mis hors tension, seul le texte ASCII est conservé. Dès sa remise sous tension, le multimètre utilise le texte ASCII pour générer un sous-programme compilé. Vous pouvez compresser les sous-programmes à l'aide de la commande COMPRESS. Dans ce cas, le texte ASCII est effacé de la mémoire permanente et le multimètre ne conserve que les versions compilées en mémoire non-permanente. Vous disposez ainsi d'un espace de mémoire permanente plus important (mais les sous-programmes enregistrés seront effacés dès que le multimètre est mis hors tension ou réinitialisé à l'aide de la touche **Reset** du panneau avant). L'instruction suivante comprime le programme précédemment enregistré sous le nom de *DCCUR1*.

```
OUTPUT 722; "COMPRESS DCCUR1"
```

Suppression des sous-programmes

La commande DELSUB permet de supprimer un sous-programme particulier. Par exemple, pour supprimer le sous-programme *DCCUR1*, envoyez:

```
OUTPUT 722; "DELSUB DCCUR1"
```

Vous pouvez également supprimer tous les sous-programmes et tous les états précédemment sauvegardés à l'aide de la commande SCRATCH.

Utilisation de la mémoire d'état

Vous pouvez sauvegarder la configuration courante du multimètre (fonction de mesure, gamme, résolution, temps d'intégration, etc.) dans la mémoire d'état de l'instrument. Les sous-programmes, les lectures et le contenu de certains registres mathématiques (voir commande SSTATE dans le [chapitre 6](#) pour plus de détails) ne sont pas sauvegardés dans l'état. En cas de coupure secteur, le multimètre sauvegarde sa configuration courante sous l'état 0. Si vous enregistrez un état dans le registre 0, il sera remplacé par la configuration courante de l'instrument en cas de coupure secteur. Le multimètre dispose de 14 Ko de mémoire, utilisée à la fois par les sous-programmes et les états. Chaque état occupe environ 300 octets. Si aucun sous-programme n'est enregistré, le multimètre peut sauvegarder jusqu'à 46 états. Lorsque la mémoire réservée aux sous-programmes et aux états est pleine, le multimètre génère l'erreur *Memory Error* (bit 7 dans le registre d'erreur).

Sauvegarde des états

La commande SSTATE permet de sauvegarder l'état courant du multimètre sous un nom permettant de l'identifier. Le nom d'un état peut comporter 10 caractères au maximum (caractères alphabétiques ou alphanumériques. Les caractères `?` et `_` sont également acceptés). Vous pouvez également utiliser un entier compris entre 0 et 127 comme nom d'état. Le premier caractère d'un nom alphanumérique doit toujours être alphabétique. Aucun nom d'état (alphabétique ou alphanumérique) ne doit être identique à une commande ou à un paramètre du multimètre ni à un sous-programme sauvegardé. Lorsque vous utilisez un entier comme nom d'état, le multimètre lui affecte le préfixe *STATE* lorsqu'il le sauvegarde pour pouvoir le différencier d'un sous-programme dont le nom serait également un entier. Un état enregistré sous le nom 8 par exemple sera sauvegardé sous le nom *STATE8*. Pour rappeler cet état, vous pouvez utiliser le nom 8 ou *STATE8*.

Tous les états sont enregistrés en mémoire permanente (ils ne sont pas effacés à la mise hors tension de l'instrument). Le multimètre compile l'état tel qu'il a été enregistré. Cela signifie que lorsque vous le rappelez, le multimètre se configure beaucoup plus vite qu'il ne le ferait si vous aviez exécuté les commandes individuelles utilisées pour créer l'état. Pour sauvegarder l'état courant du multimètre sous le nom ACST1 par exemple, envoyez:

```
OUTPUT 722; "SSSTATE ACST1"
```

Rappel des états

La commande RSTA TE permet de rappeler un état précédemment enregistré en mémoire et configure le multimètre en fonction de cet état. Par exemple, pour rappeler l'état ACST1, envoyez:

OUTPUT 722;"RSTATE ACST1"

Vous pouvez visualiser le nom de tous les états enregistrés à partir du panneau avant en accédant à la commande RSTATE et en appuyant sur une touche fléchée (vers le haut ou vers le bas). Dès que le nom de l'état recherché s'affiche, appuyez sur **Enter** pour le rappeler.

Suppression des états

La commande PURGE permet de supprimer un état particulier. Par exemple, pour supprimer l'état ACST1, envoyez:

OUTPUT 722;"PURGE ACST1"

Vous pouvez également supprimer tous les états et tous les sous-programmes précédemment sauvegardés à l'aide de la commande SCRATCH.

Utilisation de la mémoire-tampon d'entrée

Dans l'état de mise sous tension et PRESET NORM, la mémoire-tampon d'entrée est invalidée. Cela signifie que le multimètre doit traiter chaque commande GPIB individuellement et attendre que la commande soit exécutée pour libérer le bus ou accepter une autre commande. Dans la plupart des cas, le contrôleur doit attendre que le bus soit libéré avant de pouvoir continuer, ce qui garantit la synchronisation entre le contrôleur et l'instrument. Cette caractéristique se remarque tout particulièrement avec les commandes longues à s'exécuter. Si par exemple, vous lancez le test automatique complet depuis un ordinateur distant (commande TEST), le multimètre ne libérera pas le bus avant que le test ait fini de s'exécuter, soit environ 50 secondes.

Lorsque la mémoire-tampon d'entrée est validée, le multimètre enregistre temporairement les commandes dans sa mémoire-tampon et libère aussitôt le bus. Le Keysight 3458A extrait ensuite chaque commande et les exécute une par une, dans l'ordre reçu, à partir de la mémoire-tampon. Le contrôleur peut ainsi effectuer d'autres opérations pendant que le multimètre exécute les commandes. Le programme suivant valide la mémoire-tampon d'entrée avant d'exécuter la commande TEST.

```
10 OUTPUT 722;"INBUF ON"
20 OUTPUT 722;"TEST"
30 END
```

La mémoire-tampon d'entrée peut contenir jusqu'à 255 caractères. Si vous envoyez plus de caractères que la mémoire-tampon ne peut en contenir, le multimètre ne libère pas immédiatement le bus mais attend que de l'espace se libère. Dès que c'est fait, les commandes restantes sont placées dans la mémoire-tampon d'entrée et le bus est libéré.

Si vous utilisez la mémoire-tampon d'entrée, il peut être nécessaire de savoir quand toutes les commandes en mémoire ont été exécutées. Le Keysight 3458A fournit cette information en positionnant le bit 4 ("Prêt pour instructions") du registre d'état (décrit ci-après). Si le registre d'état est correctement validé, il placera la ligne de demande de service (SRQ) du bus GPIB à vrai. Votre contrôleur en accusera réception, s'il a été précédemment programmé pour accepter les SRQ comme des interruptions.

Utilisation du registre d'état

Le registre d'état contrôle les informations relatives aux états suivants du multimètre:

- Sous-programme terminé
- Dépassement de limite supérieure ou inférieure
- Commande SRQ exécutée
- Mise sous tension
- Prêt pour instructions
- Erreur
- Demande de service
- Données disponibles

Lorsque l'un de ces événements survient, il positionne le bit lui correspondant dans le registre d'état. La liste suivante définit la signification de chacun des bits du registre d'état:

Bit 0 (poids = 1) SOUS-PROGRAMME TERMINE—un sous-programme enregistré a été exécuté.

Bit 1 (poids = 2) Haut/Bas —dépassement de la limite supérieure ou inférieure de la fonction mathématique Pass/Fail. Ce bit se rapporte à la fois aux fonctions mathématiques en temps réel et après traitement. (Voir **Pass/Fail (Réussite/Echec)** au **chapitre 4**.)

Bit 2 (poids = 4) PANNEAU AVANT—la commande SRQ a été exécutée à partir du panneau avant.

Bit 3 (poids = 8) MISE SOUS TENSION—Indique l'occurrence d'un cycle de mise sous tension.

Bit 4 (poids = 16) PRET POUR INSTRUCTIONS—le Keysight 3458 a terminé l'exécution de toutes les commandes et est prêt à accepter d'autres commandes ou événements de déclenchement. (Ce bit peut être utilisé pour indiquer quand un groupe de mesures est terminé si la commande TRIG SGL ou TARM SGL est utilisée pour déclencher le groupe de mesures et que la mémoire tampon d'entrée est invalidée).

Bit 5 (poids = 32) ERREUR—indique qu'une erreur a été consignée dans le registre d'erreur auxiliaire. Pour plus de détails, voir [Lecture des registres d'erreur](#) plus haut dans ce chapitre.

REMARQUE

Vous pouvez empêcher qu'une ou toutes les erreurs ne positionne(nt) le bit Erreur du registre d'état à raide de la commande EMASK. Cette commande est décrite en détail dans le [chapitre 6](#).

Bit 6 (poids = 64) DEMANDE DE SERVICE—indique qu'un service est demandé et que la ligne SRQ est validée. Ce bit sera positionné lorsqu'un autre bit de ce registre est positionné et a été validé pour demander un SRQ par la commande RQS. Il est possible que le bit 6 soit le seul bit positionné par exemple lorsqu'une erreur positionne un bit dans le registre d'erreur qui, à son tour, positionne le bit 6. Ensuite, le registre d'erreur est lu ce qui efface le bit d'erreur mais laisse le bit 6 positionné.

Bit 7 (poids = 128) DONNEES DISPONIBLES—Une lecture ou la réponse à une interrogation est disponible dans la mémoire-tampon de sortie.

Lecture du registre d'état

La commande d'interrogation STB? lit le registre d'état et retourne la somme des poids de tous les bits positionnés. La commande STB? n'efface pas le registre d'état. Le programme ci-dessous utilise la commande STB? pour lire le contenu du registre d'état.

```
10 OUTPUT 722."STB?"
20 ENTER 722; A
30 PRINT A
40 END
```

Supposons par exemple que le bit 3 (poids 8) et le bit 7 (poids 128) soient positionnés. Dans ce cas, le programme ci-dessus retourne la somme des deux poids soit 136.

La commande STB? n'indiquera jamais que le bit 4 (Prêt pour instructions) est positionné puisque le Keysight 3458A est occupé à traiter la commande d'interrogation et n'est par conséquent pas prêt. Si vous souhaitez surveiller le bit Prêt, vous devez utiliser la commande GPIB de scrutation série pour lire le registre d'état. Si la ligne SRQ est à vrai, la commande de scrutation série efface (remet à 0) tous les bits du registre d'état*. La ligne SRQ passe à faux si le bit 6 est à zéro.

Si la ligne SRQ est à faux pendant la scrutation série (SPOLL), le contenu du registre n'est pas modifié. Le programme suivant montre comment lire le registre d'état à l'aide de la commande (GPIB) de scrutation série.

```
10 P=SPOLL(722)
20 DISP P
30 END
```

Pour effacer le registre d'état,^[1] envoyez:

```
OUTPUT 722; "CSB"
```

Interruptions

Lorsqu'un bit du registre d'état est positionné et a été validé pour générer une demande de service (commande RQS), le multimètre place la ligne SRQ (du bus GPIB) à vrai. Cela permet d'alerter le contrôleur pour qu'il interrompe la tâche en cours et identifie le service requis par le multimètre. (Pour plus de détails sur la programmation du contrôleur pour qu'il réponde à une interruption, se reporter au manuel d'utilisation du contrôleur).

Pour autoriser l'un quelconque de ces bits à valider la ligne SRQ, vous devez d'abord les valider avec la commande RQS. Par exemple, supposons que votre application demande une interruption si une limite inférieure ou supérieure est dépassée, en cas d'erreur, ou de cycle de mise sous tension du Keysight 3458. En se référant à la liste ci-dessus, cela correspond respectivement aux bits 1, 3, et 5. Les valeurs de ces bits sont 21, 23, et 25 soit 2, 8, et 32. La somme de ces valeurs est 42. Il faut donc envoyer la commande **OUTPUT 722; "RQS 42"** pour autoriser ces conditions à positionner le bit 6 et demander un SRQ.

Maintenant, à chaque fois que l'un des événements associés aux bits 1, 3 ou 5 se produit, il entraîne le positionnement du bit 6 et donc un SRQ. Maintenant, à chaque fois que l'un des événements associés aux bits 1, 3 ou 5 se produit, il entraîne le positionnement du bit 6 et donc un SRQ. Remarquez que les bits non validés répondent toujours à leur condition. Cependant, ils ne peuvent positionner le bit 6 ou activer la ligne SRQ. Le programme suivant montre un exemple d'interruptions utilisant le BASIC Keysight série 200/300.

```
10 !HI/LO LIMIT EXCEEDED,ERROR, POWER CYCLED INTERRUPT
20 OUTPUT 722;"PRESET NORM"
30 OUTPUT 722; "CSB"
```

[1] Les bits 4, 5 et 6 ne sont pas effacés si la (ou les) condition(s) qui positionnent ces bits existent toujours.

```

40 ON INTR 7 GOTO 90
50 ENABLE INTR 7;2
60 OUTPUT 722;"RQS 42;MATH PFAIL;SMATH MIN -5;SMATH MAX 5"
70 OUTPUT 722;"TRIG AUTO"
80 GOTO 80
90 OUTPUT 722; "STB?"
100 ENTER 722;A
110 IF BINAND (A,2) THEN PRINT "HI/LO LIMIT EXCEEDED"
120 IF BINAND (A,8) THEN PRINT "POWER WAS CYCLED"
130 IF BINAND (A,32) THEN PRINT "ERROR OCCURRED"
140 END

```

La ligne 20 préconfigure le multimètre, ce qui suspend les déclenchements. La ligne 30 efface le registre d'état. La ligne 40 demande au contrôleur d'aller à la ligne 90 en cas d'interruptions. La ligne 50 valide les interruptions SRQ sur l'interface GPIB. La ligne 60 valide les bits de limites haut/bas, de mise sous tension et d'erreur. La ligne 60 valide également la fonction mathématique Réussite/Echec (Pass/Fail) en temps réel en définissant la limite inférieure à - 5 et la limite supérieure à + 5. La ligne 70 valide le déclenchement automatique. La ligne 80 force le contrôleur à attendre une interruption. Les lignes 90 à 130 lisent le registre d'état et impriment la ou les conditions à l'origine de l'interruption.

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4 Les mesures

Introduction	126
Déclenchement des mesures	127
Formats de lecture	148
Utilisation de la mémoire de lecture	152
Transfert des lectures par le bus GPIB	158
Augmentation de la vitesse de lecture	166
Le Signal EXTOUT	181
Opérations mathématiques	189

Introduction

Ce chapitre traite des méthodes de déclenchement des mesures, des formats de lecture, explique comment utiliser la mémoire de lecture et comment transmettre des lectures par le bus GPIB. Il vous apprendra également à augmenter la vitesse de lecture et la vitesse de transfert par le bus GPIB, à mesurer la vitesse de lecture ainsi qu'à utiliser le signal Ex.TOUT du multimètre et les fonctions mathématiques de l'instrument.

Déclenchement des mesures

Avant que le 3458A puisse effectuer une lecture ou une série de lectures, trois événements distincts (1) l'événement d'armement de déclenchement, (2) l'événement de déclenchement et (3) l'événement d'échantillonnage doivent être satisfaits, et dans l'ordre indiqué. Le sous-échantillonnage (décrit dans le [chapitre 5](#)) et l'armement multiple (décrit dans ce chapitre) constituent les deux seules exceptions à cette hiérarchie de déclenchement. Comme l'illustre la [figure 4-1](#), lorsque les trois événements se sont produits dans cet ordre, le multimètre commence la ou les mesure(s) spécifiée(s). Dans l'état de mise sous tension, l'instrument est configuré pour lire en continu (les trois événements sont en mode AUTOMatique). Dans la plupart des applications, vous n'aurez à utiliser qu'un seul ou deux de ces événements et à laisser celui ou ceux qui reste(nt) à AUTO. Cette partie décrit les différents événements qui peuvent être utilisés pour satisfaire les conditions d'armement, de déclenchement et d'échantillonnage et renferme plusieurs exemples qui illustrent l'utilisation de ces événements.

REMARQUE

Les exemples figurant dans ce manuel s'appliquent à des ordinateurs Hewlett-Packard série 2001300 utilisant le langage HP BASIC. Ils supposent que le code de sélection de l'interface GPIB est 7, l'adresse de l'instrument 22, ce qui donne l'adresse GPIB 722. Certains exemples sauvegardent les lectures en mémoire alors que d'autres les transmettent au contrôleur par le bus GPIB. La destination de la lecture est décrite en détail dans ce chapitre (voir [Utilisation de la mémoire de lecture](#) et [Transfert des lectures par le bus GPIB](#)).

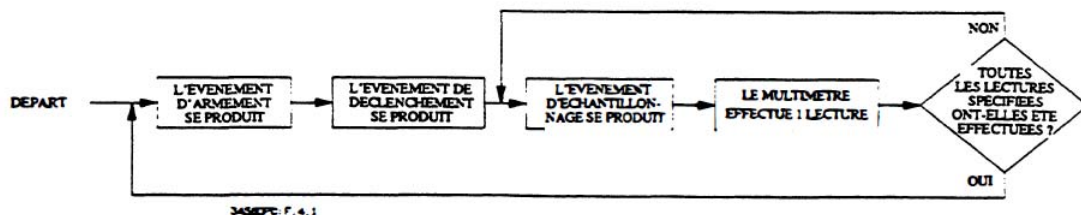


Figure 4-1 Hiérarchie des déclenchements

L'événement d'armement de déclenchement

Lorsque l'événement d'armement de déclenchement spécifié se produit, il “arme” la fonction de déclenchement du multimètre, c'est-à-dire qu'il valide l'événement de déclenchement qui suit. Vous spécifiez l'événement d'armement de déclenchement à l'aide de la commande TARM.

L'événement de déclenchement

Lorsque l'événement de déclenchement spécifié se produit (et que l'événement d'armement du déclenchement s'est déjà produit), il valide l'événement d'échantillonnage qui suit. Vous spécifiez l'événement de déclenchement à l'aide de la commande TRIG.

L'événement d'échantillonnage

Lorsque l'événement d'échantillonnage se produit (et que les événements d'armement et de déclenchement se sont déjà produits), le multimètre effectue une mesure. Il effectuera une lecture par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint. Le premier paramètre de la commande NRDGS (nombre de lectures) spécifie le nombre de lectures par événement de déclenchement. Le second paramètre spécifie l'événement (d'échantillonnage) qui initialise chaque lecture.

Choix d'événements

Pour vos événements d'armement de déclenchement, de déclenchement et d'échantillonnage, vous disposez d'un choix assez étendu. Le [tableau 4-1](#) décrit les paramètres de chaque événement et la commande à laquelle ils s'appliquent.

Tableau 4-1 Paramètres d'événements

Paramètre d'événement	Utilisé avec			Description de l'événement
	TARM	TRIG	NRDGS	
AUTO	✓	✓	✓	Se produit automatiquement (à chaque fois que cela est nécessaire)
EXT	✓	✓	✓	Se produit au moment de la transition négative d'une impulsion TTL sur la borne d'entrée de déclenchement externe du multimètre
HOLD	✓	✓		Suspend les mesures
LEVEL ^[a]		✓	✓	Se produit lorsque la tension spécifiée est atteinte sur la pente spécifiée du signal d'entrée
LINE ^[b]		✓	✓	Se produit lorsque la tension secteur passe par 0 volts
SGL	✓	✓		Ne se produit qu'une seule fois (à réception d'une commande TARM SGL ou TRIG SGL, après quoi il passe à HOLD)
SYN	✓	✓	✓	Se produit lorsque la mémoire-tampon de sortie du multimètre est vide, que la mémoire de lecture est invalidée ou vide et que le cont.rôleur demande des données
TIMER ^[b]			✓	Se produit automatiquement en fonction de l'intervalle spécifié entre les lectures

[a] L' événement de déclenchement ou d' échantillonnage LEVEL ne peut être utilisé que pour les numérisations (de tensions continues ou d'échantillons directs).

[b] L'événement TIMER ou LINE ne peut pas être utilisé pour les tensions alternatives ou alternatives + continues mesurées par la méthode synchrone ou aléatoire ni pour les mesures de fréquence ou de période.

Lectures continues

Dans l'état de mise sous tension, les événements d'armement, de déclenchement et d'échantillonnage du multimètre sont en mode AUTO, c'est-à-dire que le multimètre procède continuellement à des mesures. Typiquement, il est conseillé de suspendre les lectures avant la configuration du multimètre à l'aide de la commande TARM HOLD ou TRIG HOLD ou en plaçant l'instrument dans un de ses

états de préconfiguration (voir [Suspension des lectures](#) dans le [chapitre 3](#)). Après avoir configuré le multimètre, vous pouvez reprendre les lectures en continu (à condition que les autres événements de déclenchement n'aient pas été modifiés) en envoyant:

```
OUTPUT 722;"TARM AUTO" ! Reprend les cycles de lecture
                        ! précédemment suspendus par TARM HOLD,
                        ! PRESET FAST ou PRESET DIG
```

ou

```
OUTPUT 722; "TRIG AUTO" ! Reprend les cycles de lecture
                        ! précédemment suspendus par TRIG HOLD ou
                        ! PRESET NORM
```

Lectures uniques

La commande NRDGS spécifie le nombre de lectures effectuées par événement de déclenchement et l'événement d'échantillonnage qui initialise chaque lecture. Dans les états de mise sous tension, RESET, PRESET NORM et PRESET FAST, le nombre de lectures par déclenchement est de 1 et l'événement d'échantillonnage est en mode AUTO (NRDGS 1,AUTO). Lorsque le multimètre est dans l'un de ces états, vous pouvez commencer une lecture unique en exécutant la commande TARM SGL ou 1RIG SGL (suivant l'événement, s'il y en a un, qui suspend les lectures). Le programme suivant par exemple réinitialise le multimètre et suspend les lectures en mettant l'événement d'armement de déclenchement à HOLD. La configuration est modifiée (lignes 30 à 50) et la ligne 60 déclenche une lecture unique qui est transmise au contrôleur et imprimée. Après la lecture unique, l'événement d'armement de déclenchement devient HOLD, et les lectures sont suspendues.

```

10 OUTPUT 722;"RESET"      ! REINITIALISATION; TOUS LES EVENEMENTS
15                          ! DE DECLENCHEMENT SONT A AUTO
20 OUTPUT 722;"TARM HOLD"  ! SUSPEND LES LECTURES
30 OUTPUT 722;"DCV 10"     ! TENSION CONTINUE, GAMME 10 V
40 OUTPUT 722;"NPLC 1"     ! TEMPS D'INTEGRATION : 1 PERIODE SECTEUR
50 OUTPUT 722;"AZERO OFF"  ! AUTO-ZERO INVALIDE
60 OUTPUT 722;"TARM SGL"   ! DECLENCHE 1 LECTURE
70 ENTER 722;A             ! ENTRE LA LECTURE
80 PRINT A                 ! IMPRESSION DE LA LECTURE
90 END

```

Dans l'état PRESET NORM, les lectures sont suspendues car l'événement de déclenchement est défini à SYN (l'événement SYN est décrit plus loin dans ce chapitre). Lorsque le multimètre est dans cet état, vous pouvez commencer une lecture unique en exécutant la commande TRIG SGL. Dans le programme suivant par exemple, la ligne 10 suspend les lectures en mettant l'événement de déclenchement à SYN. La ligne 20 déclenche une lecture unique qui est transmise au contrôleur et imprimée. Une fois la commande 1RIG SGL exécutée, l'événement de déclenchement devient HOLD, et les lectures sont suspendues.

```

10 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION :TARM AUTO, TRIG
15                          ! SYN, NRDGS 1, AUTO
20 OUTPUT 722;"TRIG SGL"   ! DECLENCHE 1 LECTURE

```

```
30 ENTER 722;A  
40 PRINT A  
50 END
```

```
! ENTRE LA LECTURE  
! IMPRESSION DE LA LECTURE
```


Lectures multiples

Vous pouvez utiliser la commande NRDGS pour spécifier plus d'une lecture par événement de déclenchement. Le programme suivant par exemple effectue 10 lectures par événement de déclenchement (une seule lecture est effectuée par événement d'échantillonnage) et les transmet au contrôleur. Vous remarquerez que la mémoire-tampon d'entrée est validée (ligne 40). Si elle était invalidée, l'événement SGL (ligne 60) conserverait le bus jusqu'à ce que le nombre spécifié de lectures ait été atteint. Ceci empêcherait la ligne 70 de transférer la dernière lecture au contrôleur. Le fait de valider la mémoire-tampon d'entrée empêche la commande 1RIG SGL de monopoliser le bus et permet le transfert de chaque lecture dès qu'elle est disponible.

```

10 OPTION BASE 1           ! BORNE INFERIEURE DU TABLEAU A 1
20 DIM Rdgs(10)            ! DIMENSIONNE LE TABLEAU POUR 10 LECTURES
30 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION :TARM AUTO, TRIG
35                          ! SYN, DCV AUTORANGE
40 OUTPUT 722;"INBUF ON"   ! VALIDE LA MEMOIRE-TAMPON D'ENTREE
50 OUTPUT 722;"NRDGS 10,"  ! 10 LECTURES/DECLenchement,
55                          ! EVENEMENT D'ECHANTILLONNAGE AUTO
60 OUTPUT 722;"TRIG SGL"   ! DECLenchement DES LECTURES
70 ENTER 722;Rdgs(*)       ! ENTRE LES LECTURES
80 PRINT Rdgs(*)           ! IMPRESSION DES LECTURES
90 END

```

Armement multiple

Le second paramètre de la commande TARM vous permet de spécifier un armement multiple. Dans ce cas, dès que l'événement d'armement spécifié se produit, il arme le multimètre pour le nombre de déclenchements spécifiés. (Pour un armement multiple, l'événement d'armement de déclenchement doit être SGL). Ceci force le multimètre à effectuer des séries de mesures multiples, comme illustré à la [figure 4-2](#).

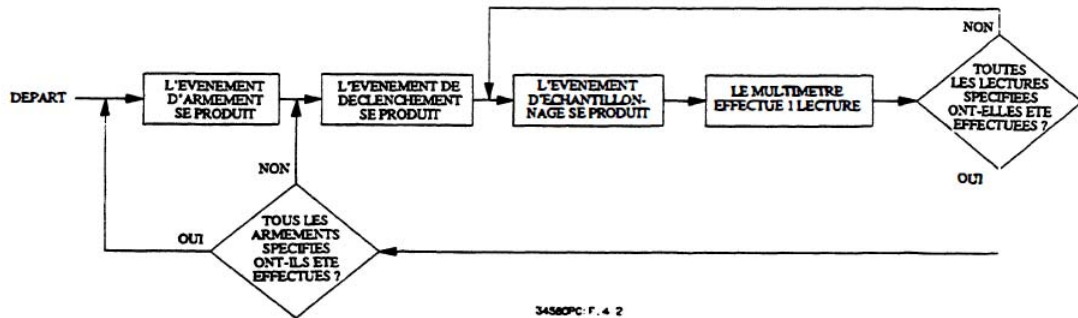


Figure 4-2 Armement d'un déclenchement multiple

Dans le programme suivant, la commande NRDGS sélectionne 10 lectures par événement de déclenchement. Le second paramètre de la commande TARM spécifie 5 armements. Ce programme enregistre 5 séries de 10 lectures soit un total de 50 lectures.

```

10  OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A 1
20  DIM Rdgs(50)                 ! DIMENSIONNE LE TABLEAU POUR 50 LECTURES
30  OUTPUT 722;"PRESET NORM"     ! PRECONFIGURATION : TARM AUTO, TRIG
35                                ! SYS, DCV AUTORANGE
40  OUTPUT 722;"TARM HOLD"       ! EVENEMENT D'ARMEMENT DE DECLenchement A
45                                ! HOLD
50  OUTPUT 722;"TRIG AUTO"       ! EVENEMENT DE DECLenchement A AUTO
60  OUTPUT 722;"INBUF ON"        ! VALIDE LA MEMOIRE-TAMPON D'ENTREE
70  OUTPUT 722;"NRDGS 10,AUTO"! 10 LECTURES/DECLenchement,
75                                ! EVENEMENT D'ECHANTILLONNAGE AUTO
80  OUTPUT 722;"TARM SGL,5"      ! 5 ARMEMENTS DE DECLenchement
90  ENTER 722;Rdgs(*)            ! ENTRE LES LECTURES
100 PRINT Rdgs(*)                ! IMPRESSION DES LECTURES
110 END
  
```

Lectures synchrones

Vous pouvez synchroniser le multimètre sur le contrôleur en définissant l'événement d'armement, de déclenchement et/ou d'échantillonnage en mode synchrone (SYN). L'événement synchrone se produit à chaque fois que la mémoire-tampon de sortie du multimètre est vide, que la mémoire de lecture est invalidée ou vide et que le contrôleur réclame des données. Ce qui signifie que les mesures sont prises à chaque fois que le contrôleur le demande. Cette caractéristique est très importante lorsque le multimètre est commandé à distance surtout en mode grande vitesse.

En mode grande vitesse, l'événement synchrone permet de s'assurer que le contrôleur est prêt à accepter des lectures et qu'il n'affectera pas la vitesse de lecture. Le mode de transfert à grande vitesse est expliqué plus loin dans ce chapitre. Dans le programme suivant, la commande PRESET NORM définit l'événement de déclenchement en mode synchrone. La ligne 40 spécifie 15 lectures par événement de déclenchement synchrone. La ligne 50 demande des données au multimètre. Ceci satisfait la condition de déclenchement synchrone et initialise les mesures. Vous remarquerez que la ligne 50 demande 15 fois des données au multimètre. Lorsque vous spécifiez des lectures multiples et que SYN est utilisé comme événement de déclenchement ou d'armement de déclenchement, le multimètre ne reconnaît pas les demandes de données multiples comme des événements SYN individuels. C'est-à-dire que dans ce programme l'événement SYN se produit une fois et non pas 15.

```

10 OPTION BASE 1           ! BORNE INFERIEURE DU TABLEAU A 1
20 DIM Rdgs (15)           ! DIMENSIONNE LE TABLEAU POUR:5 LECTURES
30 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION : TARM AUTO, TRIG
35                          ! SYN, DCV AUTORANGE, MEM OFF
40 OUTPUT 722;"NRDGS 15,AUTO" ! 15 LECTURES/DECLenchement,
45                          ! EVENEMENT D'ECHANTILLONNAGE AUTO
50 ENTER 722;Rdgs(*)        ! ENTRE LES LECTURES
60 PRINT Rdgs(*)            ! IMPRESSION DES LECTURES
70 END

```

Le programme suivant utilise l'événement synchrone comme événement d'échantillonnage. La ligne 60 demande 15 fois des données au multimètre. Lorsque SYN est utilisé comme événement d'échantillonnage, chaque demande de données est reconnue comme un événement SYN. C'est-à-dire que dans ce programme l'événement SYN se produit 15 fois.

```

10 OPTION BASE 1           ! BORNE INFERIEURE DU TABLEAU A 1
20 DIM Rdgs(15)            ! DIMENSIONNE LE TABLEAU POUR 15 LECTURES
30 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION : TARM AUTO, TRIG
35                          ! SYN, DCV AUTORANGE
40 OUTPUT 722;"NRDGS 15,SYN" ! 5 LECTURES/DECLenchement,
45                          ! EVENEMENT D'ECHANTILLONNAGE SYN
50 OUTPUT 722;"TRIG AUTO"   ! EVENEMENT DE DECLenchement A AUTO
60 ENTER 722;Rdgs(*)        ! ENTRE LES LECTURES
70 DISP Rdgs(*)            ! AFFICHAGE DES LECTURES
80 END

```

Lectures à intervalles réguliers

Lorsque vous effectuez plusieurs lectures par déclenchement, vous pouvez utiliser l'événement d'échantillonnage TIMER pour spécifier un intervalle de temps entre les lectures. Cet intervalle correspond au temps qui s'écoule depuis le début d'une lecture jusqu'au début de la lecture suivante. Vous spécifiez cet intervalle en secondes à l'aide de la commande TIMER. (Si 1 'intervalle spécifié est inférieur au temps requis pour effectuer les mesures, le multimètre génère l'erreur TRIG TOO FAST - Déclenchement trop rapide). Le programme suivant spécifie 8 lectures par déclenchement avec un intervalle de 1 seconde entre chaque lecture (illustré à la [figure 4-3](#)).

```

10 OPTION BASE 1           ! BORNE INFERIEURE DU TABLEAU A1
20 DIM Rdgs(8)            ! DIMENSIONNE LE TABLEAU POUR 8 LECTURES
30 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION : TARM AUTO, TRIG
35                          ! SYN, DCV AUTORANGE
40 OUTPUT 722;"NRDGS 8, TIMER"! 8 LECTURES/DECLenchement,
45                          ! EVENEMENT D'ECHANTILLONNAGE TIMER
50 OUTPUT 722;"TIMER 1"    ! 1 SECONDE D'INTERVALLE ENTRE LES
55                          ! MESURES
60 ENTER 722;Rdgs(*)      ! EVENEMENT SYN, ENTRE CHAQUE LECTURE
70 PRINT Rdgs(*)          ! IMPRESSION DES LECTURES
80 END

```

Vous pouvez également utiliser la commande SWEEP pour remplacer la commande NRDGS n,TIMER et la commande TIMER. Le premier paramètre de la

commande SWEEP spécifie l'intervalle entre les lectures et son second paramètre, le nombre de lectures. (Les commandes SWEEP et NRDGS sont interchangeables; le multimètre utilise la dernière des deux qui a été programmée). Le programme suivant par exemple spécifie également 8 lectures avec un intervalle de 1 seconde entre les lectures (illustré à la [figure 4-3](#)).

```

10 OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A1
20 DIM Rdgs(8)                  ! DIMENSIONNE LE TABLEAU POUR 8 LECTURES
30 OUTPUT 722;"PRESET NORM"      ! PRECONFIGURATION : TARM AUTO, TRIG
35                               ! SYN, DCV AUTORANGE
40 OUTPUT 722;"SWEEP 1,8"        ! INTERVALLE DE 1 SECONDE,
45                               ! 8 LECTURES/DECLenchement,
50 ENTER 722; Rdgs(*)            ! EVENEMENT SYN, ENTRE CHAQUE LECTURE
60 PRINT Rdgs(*)                 ! IMPRESSION DES LECTURES
70 END

```

REMARQUE

Lorsque vous utilisez l'événement l'échantillonnage TIMER ou la commande SWEEP, la fonction de changement de gamme automatique est invalidée. D'oe. are part, vous ne pouvez pas utiliser TIMER ou SWEEP pour mesurer des tensions alternatives ou alternatives + continues à l'aide des méthodes d'échantillonnage synchrone ou aléatoire (SETACV SYNC ou RNDM), ou encore pour mesurer des fréquences ou des périodes.

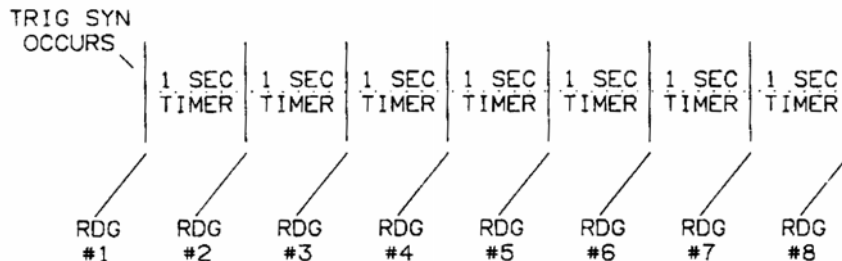


Figure 4-3 Intervalle TIMER ou SWEEP

Lectures à retardement

La commande DELAY vous permet de spécifier un intervalle de temps entre l'événement de déclenchement et le premier événement d'échantillonnage. Dans le programme suivant par exemple, le retard spécifié est de 2 secondes et l'intervalle SWEEP (entre les mesures) est de 1 seconde. La ligne 40 spécifie 8 lectures par événement de déclenchement. La [figure 4-4](#) montre que le retard spécifié s'insère entre l'événement de déclenchement (TRIG SGL) et la première lecture. L'intervalle SWEEP est alors pris en compte entre chaque lecture successive. Dans cet exemple, le laps de temps ajouté à la mesure est de 9 secondes.

```

10 OPTION BASE 1           ! BORNE INFERIEURE DU TABLEAU A 1
20 DIM Rdgs(8)             ! DIMENSIONNE LE TABLEAU POUR 8 LECTURES
30 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION : TARM AUTO, TRIG
35                          ! SYN, DCV AUTORANGE
40 OUTPUT 722;"SWEEP 1,8"  ! INTERVALLE DE 1 SECONDE,
45                          ! 8 LECTURES/DECLenchement,
50 OUTPUT 722;"DELAY 2"    ! LECTURE RETARDEE DE 2 SECONDES
60 ENTER 722;Rdgs(*)       ! ENTRE LES LECTURES
70 PRINT Rdgs(*)           ! IMPRESSION DES LECTURES
80 END

```

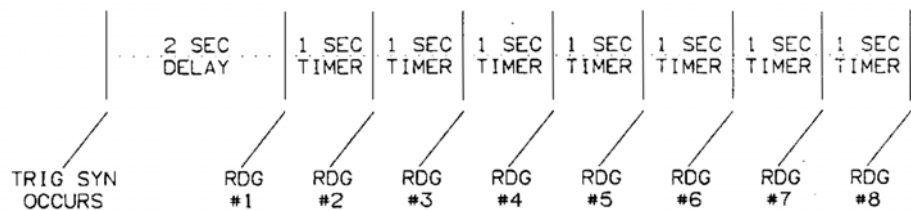


Figure 4-4 DELAY avec SWEEP (ou TIMER)

Retard par défaut

Si vous n'avez spécifié aucun retard, le multimètre détermine automatiquement une valeur de retard (par défaut) basée sur la fonction de mesure, la gamme, la résolution et la largeur de bande ca courantes. Ce retard correspond en fait au temps d'établissement autorisé avant les lectures, ce qui garantit la précision des mesures. La valeur de retard est automatiquement réactualisée à chaque fois que la fonction, la gamme, la résolution ou la largeur de bande ca est modifiée. Si toutefois vous spécifiez une valeur de retard, celle-ci ne change pas tant que (1) vous ne réinitialisez pas l'instrument (RESET ou PRESET), (2) vous ne le mettez pas hors tension, (3) vous ne spécifiez pas une autre valeur de retard ou (4) vous ne prenez pas la valeur par défaut du paramètre de retard (DELAY -1, commande qui revalide le retard automatique). Le programme suivant utilise la commande d'interrogation DELAY? pour connaître la valeur de retard de l'état PRESET NORM.

```
10 OUTPUT 722;"PRESET NORM"
20 OUTPUT 722;"DELAY?"
30 ENTER 722;A$
40 PRINT A$
50 END
```

Déclenchements externes

L'événement externe (EXT) permet de déclencher le multimètre à partir d'une source externe. Cet événement peut être utilisé comme événement d'armement, de déclenchement et/ou d'échantillonnage. L'événement EXT se produit au moment de la transition négative d'une impulsion TTL sur la borne de déclenchement externe (**Ext Trig**), située sur le panneau arrière du multimètre. La largeur minimale d'impulsion reconnue est de 250 ns. La largeur de bande des circuits de déclenchement externe est de 5 MHz.

Le programme suivant utilise l'événement EXT comme événement de déclenchement. Le nombre de lectures par déclenchement est défini à 1. Dès qu'une transition négative se produit sur la borne **Ext Trig**, le multimètre effectue une mesure (lecture) et la transmet au contrôleur. Une seconde transition négative initialise la seconde lecture qui est à son tour transmise au contrôleur. Cette séquence se poursuit jusqu'à ce que 20 lectures aient été faites et transmises au contrôleur.

```
10 OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A 1
20 DIM Rdgs(20)                ! DIMENSIONNE LE TABLEAU POUR 20 LECTURES
```

```

30 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION :TARM AUTO, TRIG
35                               ! SYN, NRDGS 1,AUTO
50 OUTPUT 722;"TRIG EXT"     ! DECLENCHEMENT DE CHAQUE LECTURE
60 ENTER 722;Rdgs(*)         ! ENTRE LES LECTURES
70 PRINT Rdgs(*)             ! IMPRESSION DES LECTURES
80 END

```

L'exemple suivant utilise EXT comme événement d'échantillonnage. Le déclenchement est synchrone (valeur par défaut dans l'état PRESET NORM). Il y a 10 lectures par déclenchement. Lorsque le contrôleur exécute la ligne 50, l'événement synchrone se produit et valide l'événement d'échantillonnage (EXT). Dès qu'une transition négative se produit sur la borne **Ext Trig**, le multimètre effectue une mesure (lecture) et la transmet au contrôleur. Une seconde transition négative initialise la seconde lecture qui est à son tour transmise au contrôleur. Cette séquence se poursuit jusqu'à ce que 10 lectures aient été faites et transmises au contrôleur.

```

10 OPTION BASE 1              ! BORNE INFERIEURE DU TABLEAU A 1
20 DIM Rdgs (10)              ! DIMENSIONNE LE TABLEAU POUR 10 LECTURES
30 OUTPUT 722;"PRESET NORM"   ! PRECONFIGURATION : TARM AUTO, TRIG
35                               ! SYN, DCV AUTORANGE
40 OUTPUT 722;•NRDGS 10,EXT"  ! 10 LECTURES/DECLENCHEMENT,
45                               ! ECHANTILLONNAGE EXTERNE
50 ENTER 722; Rdgs(*)         ! ENTRE LES LECTURES
60 PRINT Rdgs (*)             ! IMPRESSION DES LECTURES
70 END

```

REMARQUE

Voir "Signal EXTOUT" plus loin dans ce chapitre où figurent des exemples montrant comment synchroniser le multimètre sur un dispositif de scrutation (scanner) externe.

Mise en mémoire-tampon des déclenchements externes

La mise en mémoire-tampon des déclenchements (commande TBUFF) compense l'éventuelle erreur TRIGGER TOO FAST (déclenchement trop rapide) qui peut se

produire lorsque vous utilisez EXT comme événement d'armement, de déclenchement ou d'échantillonnage. Si la fonction de mémorisation des déclenchements est invalidée, tout déclenchement externe survenant pendant une mesure (lecture) génère l'erreur TRIGGER TOO FAST et les déclenchements sont ignorés. Lorsque la fonction de mémorisation des déclenchements est validée, le premier déclenchement externe survenant pendant une mesure est enregistré et aucune erreur n'est générée par ce déclenchement ou les déclenchements ultérieurs. Une fois la mesure terminée, le déclenchement enregistré satisfait l'événement EXT si le multimètre a été programmé dans ce sens. La mise en mémoire-tampon des déclenchements s'avère particulièrement utile lorsqu'un scanner est synchronisé sur le signal EXTOUT du multimètre par l'événement Entrée Terminée (ICOMP). Comme l'impulsion ICOMP survient avant que la mesure ne soit terminée, le scanner risque de fermer la voie suivante et de générer une impulsion Voie Fermée (qui sert à déclencher le multimètre) avant que la mesure ne soit terminée. (Pour plus de détails à ce sujet, voir [Entrée terminée](#), plus loin dans ce chapitre). Dans l'état de mise sous tension du multimètre, la fonction de mise en mémoire tampon des déclenchements est invalidée. Pour la valider, envoyez:

OUTPUT 722;"TBUFF ON"

Pour l'invalider, envoyez:

OUTPUT 722; "TBUFF OFF"

Combinaisons d'événements

Suivant vos besoins, vous pouvez combiner plusieurs événements d'armement, de déclenchement et d'échantillonnage. Le **tableau 4-2** indique toutes les combinaisons possibles et le résultat correspondant à chacune d'elles.

Tableau 4-2 Combinaisons d'événements

Événement d'armement de déclenchement	Événement de déclenchement	Événement d'échantillonnage	Description
AUTO	AUTO	N'importe	Une mesure est prise par événement d'échantillonnage (si ce dernier est à AUTO, les mesures se succèdent en continu).
AUTO	EXT	AUTO, EXT, TIMER, LINE, LEVEL	Après une transition négative sur la borne Ext Trig, une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures (mesures) spécifié ait été atteint.
AUTO	EXT	SYN	Combinaison illégale.
AUTO	LEVEL	AUTO, EXT, TIMER, LEVEL	Dès que l'événement LEVEL ^[a] s'est produit, une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint.
AUTO	LEVEL	SYN, LINE	Combinaison illégale.
AUTO	LINE	AUTO, EXT, TIMER, LINE	Dès que la tension secteur passe par 0 Volt, une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint.
AUTO	LINE	SYN, LEVEL	Combinaison illégale.
AUTO	SGL	N'importe	Après exécution de la commande TRIG SGL, une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint. L'événement de déclenchement passe alors à HOLD. Si vous utilisez l'événement d'échantillonnage SYN, la mémoire-tampon d'entrée doit être invalidée eu vous devez supprimer le cr lf lorsque vous envoyez la commande TRIG SGL.

Tableau 4-2 Combinaisons d'événements (suite)

Événement d'armement de déclenchement	Événement de déclenchement	Événement d'échantillonnage	Description
AUTO	SYN	SYN	Après que le contrôleur ait demandé des données, ^[b] les deux événements SYN sont satisfaits et la première mesure est prise. Il y a ensuite une mesure par événement SYN jusqu'à ce que le nombre de lectures spécifié ait été atteint.
AUTO	SYN	AUTO, EXT, LEVEL, LINE, TIMER	Après que le contrôleur ait demandé des données, ^[b] une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint.
EXT	AUTO	N'importe	Après une transition négative sur la borne Ext Trig, une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint.
EXT	EXT	AUTO, EXT, TIMER, LINE, LEVEL	Après deux transitions négatives sur la borne Ext Trig, une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint.
EXT	EXT	SYN	Combinaison illégale.
EXT	LEVEL	AUTO, EXT, TIMER, LEVEL	Après une transition négative sur la borne Ext Trig, suivie d'un événement LEVEL ^[a] , une lecture est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint.
EXT	LEVEL	SYN, LINE	Combinaison interdite.
EXT	LINE	AUTO, EXT, TIMER, LINE	Après une transition négative sur la borne Ext Trig, suivie d'un passage de la tension secteur par 0 Volt, une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint.
EXT	LINE	SYN, LEVEL	Combinaison interdite.
EXT	SGL	N'importe	Combinaison interdite.

Tableau 4-2 Combinaisons d'événements (suite)

Événement d'armement de déclenchement	Événement de déclenchement	Événement d'échantillonnage	Description
EXT	SYN	SYN	Après une transition négative sur la borne Ext Trig, suivie d'une demande de données par le contrôleur ^[b] (ce qui satisfait les deux événements SYN), la première mesure est prise. Il y a ensuite une mesure par événement SYN jusqu'à ce que le nombre de lectures spécifié ait été atteint.
EXT	SYN	AUTO, EXT, TIMER, LINE, LEVEL	Après une transition négative sur la borne Ext Trig, suivie d'une demande de données par le contrôleur ^[b] une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint.
HOLD	N'importe	N'importe	Aucune mesure n'est prise tant que l'événement d'armement de déclenchement n'est pas modifié.
AUTO, EXT, SGL, SYN	HOLD	N'importe	Aucune mesure n'est prise tant que l'événement de déclenchement n'est pas modifié, à moins que l'événement d'armement de déclenchement ne se produise, suivi d'un déclenchement de groupe GPIB (TRIGGER). Si vous utilisez l'événement d'armement de déclenchement SGL et l'événement d'échantillonnage SYN, la mémoire-tampon d'entrée doit être validée ou vous devez supprimer cr lf lorsque vous envoyez la commande TARM SGL.
SGL	AUTO	N'importe	Après exécution de la commande TARM SGL, une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint. L'événement d'armement de déclenchement passe alors à HOLD. Si vous utilisez l'événement d'échantillonnage SYN, la mémoire-tampon d'entrée doit être invalidée ou vous devez supprimer le cr lf lorsque vous envoyez la commande TARM SGL.
SGL	EXT	AUTO, EXT, TIMER, LINE, LEVEL	Après exécution de la commande TARM SGL, suivie d'une transition négative sur la borne Ext Trig, une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint. L'événement d'armement de déclenchement passe alors à HOLD.

Tableau 4-2 Combinaisons d'événements (suite)

Événement d'armement de déclenchement	Événement de déclenchement	Événement d'échantillonnage	Description
SGL	EXT	SYN	Combinaison interdite.
SGL	LEVEL	AUTO, EXT, TIMER, LEVEL	Après exécution de la commande TARM SGL, suivie d'un événement LEVEL, ^[a] une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint. L'événement d'armement de déclenchement passe alors à HOLD.
SGL	LEVEL	SYN, LINE	Combinaison interdite.
SGL	LINE	AUTO, EXT, TIMER, LINE	Après exécution de la commande TARM SGL, suivie d'un passage de la tension secteur par 0 Volt, une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint. L'événement d'armement de déclenchement passe alors à HOLD.
SGL	LINE	SYN, LEVEL	Combinaison interdite.
SGL	SGL	N'importe	Combinaison interdite.
SGL	SYN	SYN	Après exécution de la commande TARM SGL, suivie d'une demande de données par le contrôleur ^[b] , (ce qui satisfait les deux événements SYN), la première mesure est prise. Il y a ensuite une mesure par événement SYN jusqu'à ce que le nombre de lectures spécifié ait été atteint. ^[c] L'événement d'armement de déclenchement passe alors à HOLD.
SGL	SYN	AUTO, EXT, TIMER, LINE, LEVEL	Après exécution de la commande TARM SGL, suivie d'une demande de données par le contrôleur, ^[b] une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint. ^[c] L'événement d'armement de déclenchement passe alors à HOLD.
SYN	AUTO	SYN	Après que le contrôleur ait demandé des données, ^[b] les deux événements SYN sont satisfaits et la première mesure est prise. Il y a ensuite une mesure par événement SYN jusqu'à ce que le nombre de lectures spécifié ait été atteint.

Tableau 4-2 Combinaisons d'événements (suite)

Événement d'armement de déclenchement	Événement de déclenchement	Événement d'échantillonnage	Description
SYN	AUTO	AUTO, EXT, TIMER, LINE, LEVEL	Après que le contrôleur ait demandé des données, ^[b] une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint.
SYN	EXT	AUTO, EXT, TIMER, LINE, LEVEL	Après une demande de données par le contrôleur, ^[b] suivie d'une transition négative sur la borne Ext Trig, une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint.
SYN	EXT	SYN	Combinaison interdite.
SYN	LEVEL	AUTO, EXT, TIMER, LEVEL	Après une demande de données par le contrôleur, ^[b] suivie d'un événement LEVEL, ^[a] une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint.
SYN	LEVEL	SYN, LINE	Combinaison interdite.
SYN	LINE	AUTO, EXT, TIMER, LINE	Après une demande de données par le contrôleur, ^[b] suivie d'un passage de la tension secteur par 0 Volt, une mesure est prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint.
SYN	LINE	SYN, LEVEL	Combinaison interdite.
SYN	SGL	N'importe	Combinaison interdite.
SYN	SYN	SYN	Après que le contrôleur ait demandé des données, ^[b] les trois événements SYN sont satisfaits et la première mesure est prise. Il y a ensuite une mesure par événement SYN jusqu'à ce que le nombre de lectures spécifié ait été atteint.
SYN	SYN	AUTO, EXT, TIMER, LINE, LEVEL	Après que le contrôleur ait demandé des données, ^[b] les deux événements SYN sont satisfaits. Une mesure est alors prise par événement d'échantillonnage jusqu'à ce que le nombre de lectures spécifié ait été atteint.

- [a] L'événement LEVEL se produit lorsque la tension spécifiée est atteinte sur la pente spécifiée du signal d'entrée. L'événement de déclenchement ou d'échantillonnage LEVEL ne peut être utilisé que pour les mesures de tensions continues ou d'échantillons directs.
- [b] La mémoire-tampon de sortie doit être vide et la mémoire de lecture doit être invalidée ou vide pour que l'événement SYN puisse se produire.
- [c] La mémoire-tampon d'entrée doit être validée ou vous devez supprimer cr lf lorsque vous envoyez la commande TARM SGL.

Formats de lecture

Cette partie traite des formats ASCII, entier simple (SINT), entier long ou double (DINT), réel simple (SREAL) et réel long ou double (DREAL) qui peuvent être utilisés pour sauvegarder les lectures ou pour les transmettre au contrôleur par le bus GPIB. La procédure de sauvegarde des lectures en mémoire est décrite plus loin dans ce chapitre [Utilisation de la mémoire de lecture](#); ainsi que celle relative aux transferts des lectures par le bus GPIB [Transfert des lectures par le bus GPIB](#).

ASCII

Le format ASCII comporte 15 octets par lecture, codés en notation scientifique en fonction des unités de volts, ampères, ohms, hertz, ou secondes standard comme suit:

SD.DDDDDDDDESDD

Où:

S = signe (+ or -)

D = 0-9

E = Délimiteur entre mantisse et exposant en base 10

Entier simple et long

Le format "entier simple" (SINT) se compose de 2 octets par lecture et le format "entier long" (DINT) de 4 octets par lecture. Les deux formats utilisent la notation complémentaire à deux.

REMARQUE

Lorsque vous utilisez le format de mémoire/sortie SINT ou DINT, le multimètre applique un facteur d'échelle aux lectures. Ce facteur dépend de la fonction de mesure, de la gamme, de la configuration du convertisseur A/N, et des fonctions mathématiques validées. Les formats SINT et DINT ne sont pas conseillés pour les mesures de fréquences ou de périodes; lorsqu'une opération mathématique (en temps réel ou après traitement) est validée (à l'exception de STAT ou de PFAIL); et enfin lorsque la fonction de changement de gamme automatique est validée.

Notation complémentaire à deux

La notation complément à deux est une méthode qui permet à un nombre binaire de représenter à la fois des entiers positifs et des entiers négatifs. Le codage complément à deux est effectué en changeant le signe, et en effet, l'équivalent décimal du bit de poids fort (bit de gauche). Quand ce bit est positionné (1) dans un nombre en complément à deux d'un octet, sa valeur est $1 \times -(2^7) = -128$; quand il est réinitialisé (0), sa valeur est $0 \times -(2^7) = 0$. Remarquez qu'un nombre en complément à deux sur un octet est compris entre -128 et 127, et non 0 et 255.

EXEMPLE:

Trouvez l'équivalent décimal du mot en complément à deux ci-dessous:

10110101 10010110

D'où l'équivalent de ce mot en complément à deux:

$$-(2^{15}) + 2^{13} + 2^{12} + 2^{10} + 2^8 + 2^7 + 2^4 + 2^2 + 2^1$$

Soit: -19050

Réel simple

Le format réel simple (SREAL) est conforme aux spécifications IEEE-754. Il comporte 32 bits, 4 octets par lecture, et est représenté par:

S	EEE	EEEE	E	MMM	MMMM	MMMM	MMMM
octet 0			octet 1			octet 2	octet 3

Où:

S est le bit de signe (1 = négatif 0 = positif)

E = exposant en base deux polarisé par 127 {pour "décoder" ces 8 bits, soustrayez 127 de leur équivalent entier}.

M = bits de mantisse (ceux à droite de la virgule). Il existe un "chiffre implicite" à gauche de la virgule. Ce chiffre est toujours supposé être "1". Cela permet une précision effective de 24 bits avec le bit de poids faible (le plus à droite) pondéré 2^{-23} . Une autre façon d'évaluer cette mantisse est de convertir ces 24 bits (on suppose le bit de poids fort égal à "1") en un entier puis de multiplier cet entier par 2^{-23} .

La valeur d'un nombre en format SREAL est calculée par:

$$(-1)^S \times (\text{mantisse}) \times 2^{(\text{exposant})}$$

Exemple SREAL

Trouvez l'équivalent décimal du nombre en format SREAL ci-dessous:

SEEEEEEE EMMMMMMM MMMMMMMM MMMMMMMM

10111011 11001000 01001000 10010000

Le bit de signe "S" est à "1", ce qui indique que le nombre est négatif.

L'exposant en base deux (01110111) est égal à:

$$2^6 + 2^5 + 2^4 + 2^2 + 2^1 + 2^0 = 119$$

Souvenez-vous que l'exposant est polarisé par 127 au niveau du 3458A. La valeur réelle est:

$$\text{exposant} - 127 = 119 - 127 = -8$$

La mantisse [1.10010000100100010010000 (Bit de poids fort supposé "1")] est égale à:

$$1 + 2^{-1} + 2^{-4} + 2^{-9} + 2^{-12} + 2^{-16} + 2^{-19} = 1.56471443177$$

Si l'on évalue la mantisse au niveau de l'octet en place du bit:

Octet 1	Octet 2	Octet 4	=	Octet 1	Octet 2	Octet 3
11001000	01001000	10010000		200	72	144

$$\text{mantisse} = 200 \times 2^{-7} + 72 \times 2^{-15} + 144 \times 2^{-23} = 1.56471443177$$

ou

$$\text{mantisse} = (200 \times 2^{16} + 72 \times 2^8 + 144) \times 2^{-23} = 1.56471443177$$

Le nombre SREAL est ensuite calculé par:

$$-1 \times 2^{-8} \times 1.56471443177 = -6.1121657491\text{E-}3$$

Réel long

Le format réel long (DREAL) est conforme aux spécifications IEEE-754. Il comporte 64 bits (8 octets) par lecture et est représenté par:

S EEE EEEE	EEEE MMMM	MMMM MMMM	MMMM MMMM
octet 0	octet 1	octet 2	octet 3
MMMM MMMM	MMMM MMMM	MMMM MMMM	MMMM MMMM
octet 4	octet 5	octet 6	octet 7

Où:

S est le bit de signe (1 = négatif, 0 = positif)

E = exposant en base deux polarisé par 1023 (pour “décoder” ces 11 bits, soustrayez 1023 de leur équivalent entier).

M = bits de mantisse (ceux à droite de la virgule). Il existe un “chiffre implicite” à gauche de la virgule. Ce chiffre est toujours supposé être “1”. Cela permet une précision effective de 53 bits avec le bit de poids faible (le plus à droite) pondéré 2^{-52} . Une autre façon d'évaluer cette mantisse est de convertir ces 53 bits (on suppose le bit de poids fort égal à “1”) en un entier puis de multiplier cet entier par 2^{-52} .

La valeur d'un nombre en format DREAL est calculée par:

$$(-1)^S \times (\text{mantisse}) \times 2^{(\text{exposant})}$$

Utilisation de la mémoire de lecture

Lorsque la mémoire de lecture est validée, le multimètre enregistre les lectures au fur et à mesure qu'elles sont prises. La mémoire de lecture offre deux modes distincts: FIFO (premier entré – premier sorti) et LIFO (dernier entré – premier sorti). En mode FIFO, la première lecture sauvegardée est la première retournée lorsque vous rappelez des lectures sans spécifier leurs numéros (lecture “implicite”, décrite plus loin dans ce chapitre). Si vous remplissez la mémoire de lecture en mode FIFO, toutes les lectures enregistrées sont conservées et les nouvelles lectures sont ignorées dès que la mémoire est pleine.

En mode LIFO, la dernière lecture sauvegardée est la première retournée lorsque vous rappelez des lectures sans spécifier leurs numéros. Si vous remplissez la mémoire de lecture en mode LIFO, les anciennes lectures sont remplacées par les nouvelles, dès que la mémoire est pleine. Vous validez la mémoire de lecture et spécifiez son mode d'utilisation à l'aide de la commande MEM. (Le fait de spécifier un mode d'utilisation de la mémoire de lecture efface automatiquement toutes les lectures précédemment enregistrées). Pour valider la mémoire de lecture et spécifier le mode LIFO par exemple, envoyez:

OUTPUT 722; "MEM LIFO"

Le multimètre ainsi configuré enregistrera les lectures. Vous pouvez ensuite invalider la mémoire de lecture et conserver toutes les lectures enregistrées intactes en envoyant:

OUTPUT 722; "MEM OFF"

Plus tard, vous pouvez revalider le mode précédemment spécifié pour enregistrer de nouvelles lectures sans perdre les précédentes en envoyant:

OUTPUT 722; "MEM CONT"

Formats de mémoire

Les lectures peuvent être sauvegardées en mémoire sous l'un des cinq formats suivants: ASCII, entier simple (SINT), entier long (DINT), réel simple (SREAL) ou réel long (DREAL). L'espace mémoire requis par chaque format est le suivant:

ASCII - 16 octets par lecture^[1]
SINT - 2 octets par lecture

[1] Le format ASCII comporte 15 octets pour la lecture plus 1 octet par lecture pour un caractère nul qui sert à séparer les lectures enregistrées au format ASCII uniquement.

DINT - 4 octets par lecture
SREAL - 4 octets par lecture
DREAL - 8 octets par lecture

Pour savoir le nombre maximal de lectures qui peuvent être enregistrées en mémoire sous un format particulier, divisez la taille de la mémoire de lecture (première réponse retournée par la commande d'interrogation MSIZE?) par le nombre d'octets par lecture indiqués ci-dessus.

- **Entier simple (SINT) ou entier long (DINT)** - Utilisez le format SINT pour les mesures à basse résolution (3,5 ou 4,5 chiffres), à la vitesse la plus élevée possible sur une gamme fixe (fonction de changement de gamme automatique invalidée). (Comme le format SINT n'utilise que 2 octets par lecture, c'est le format qui vous permettra d'enregistrer le plus de lectures). Utilisez le format DINT pour les mesures à haute résolution (5,5 chiffres ou plus), à la vitesse la plus élevée possible sur une gamme fixe.

REMARQUE

Avec les formats de mémoire SINT ou DINT, le multimètre applique un facteur d'échelle aux lectures. Ce facteur dépend de la fonction de mesure, de la gamme, de la configuration du convertisseur A/N, et des fonctions mathématiques validées. Lorsque vous rappelez des lectures, le multimètre calcule le facteur d'échelle à partir de sa configuration courante. Si la configuration a été modifiée depuis le dernier enregistrement de lectures, le multimètre risque d'utiliser un facteur d'échelle différent qui produira des lectures incorrectes. Lorsque vous rappelez des lectures, il est donc très important que le multimètre soit configuré tel qu'il l'était au moment de l'enregistrement des lectures. Les formats SINT et DINT ne sont pas conseillés pour les mesures de fréquences ou de périodes; lorsqu'une opération mathématique (en temps réel ou après traitement) est validée (à l'exception de STAT ou de PFAIL); et enfin lorsque la fonction de changement de gamme automatique est validée.

- **Réel simple (SREAL) ou réel long (DREAL)** - A la différence des formats SINT et DINT, aucun facteur d'échelle ne s'applique sur les mesures enregistrées sous ces formats qui peuvent être utilisés quelle que soit la fonction de mesure et/ou la configuration du multimètre. (Ces formats sont d'ailleurs recommandés pour les mesures utilisant la fonction de changement de gamme automatique et/ou lorsque une fonction mathématique est validée). Utilisez le format SREAL pour les mesures dont la résolution est $\leq 6,5$ chiffres. Utilisez le format DREAL pour les mesures dont la résolution est $> 6,5$ chiffres.

- **ASCII** – Ce format de mémoire peut être utilisé quelle que soit la fonction de mesure et/ou la configuration du multimètre. Comme ce format est celui qui utilise le plus d'octets par lecture, il est conseillé de ne l'utiliser que lorsque le format de sortie est ASCII, que la vitesse de mesure n'est pas critique et que le nombre de lectures à enregistrer n'est pas très élevé.

La commande MFORMA T permet de spécifier le format sous lequel les lectures seront enregistrées en mémoire (le format par défaut et de mise sous tension est SREAL). Par exemple, pour sélectionner le format "entier simple", envoyez:

OUTPUT 722; "MFORMAT SINT"

Indication de surcharge

Le multimètre indique une condition de surcharge (entrée trop importante pour la gamme) en sauvegardant la valeur $\pm 1\text{E}+38$ dans la mémoire de lecture en place de la lecture. Lorsque une valeur de surcharge est rappelée, $\pm 1\text{E}+38$ s'affiche. Lorsqu'une valeur de surcharge est transférée de la mémoire de lecture à la mémoire-tampon de sortie GPIB, elle est convertie à la valeur de surcharge correspondant au format de sortie spécifié. Pour plus de détails à ce sujet, voir [Transfert des lectures par le bus GPIB](#) plus loin dans ce chapitre.

Rappel des lectures

Vous pouvez rappeler des lectures enregistrées en mémoire par leurs numéros ou par la méthode dite de "lecture implicite". Quelque soit le format sous lequel les lectures ont été enregistrées, elles sont rappelées au format spécifié par la commande OFORMA T (pour plus de détails à ce sujet, voir [Transfert des lectures par le bus GPIB](#)). Si avant de rappeler des lectures, vous souhaitez en connaître le nombre, envoyez la commande d'interrogation MCOUNT? Le programme suivant renvoie le nombre total de lectures enregistrées.

```
10 OUTPUT 722;"MCOUNT?"
20 ENTER 722;A
30 PRINT A
40 END
```

Rappel des lectures par leurs numéros

Le multimètre affecte un numéro à chaque lecture enregistrée en mémoire. La lecture la plus récente reçoit le numéro le plus bas (1) et la plus ancienne, le numéro le plus élevé. Les lectures sont toujours numérotées de la sorte, indépendamment du mode d'enregistrement (FIFO ou LIFO). La commande

RMEM vous permet d'utiliser le numéro des lectures pour copier une lecture ou un groupe de lectures de la mémoire vers la mémoire-tampon de sortie. La commande RMEM ne supprime pas les lectures en mémoire; elle les copie simplement dans la mémoire-tampon de sortie.

La commande RMEM invalide la mémoire de lecture. Cela signifie que les lectures préalablement enregistrées sont conservées mais qu'aucune nouvelle lecture n'est sauvegardée. Le premier paramètre de la commande RMEM spécifie la lecture de départ (paramètre *first*). Le second paramètre (*count*) indique le nombre de lectures à rappeler à partir de la lecture de départ. Le troisième paramètre (*record*) spécifie l'enregistrement à partir duquel seront rappelées les lectures. Les enregistrements correspondent au nombre de lectures spécifiées dans la commande NRDGS ou SWEEP. Si par exemple vous avez spécifié quatre lectures dans la commande NRDGS, chaque enregistrement en mémoire de lecture contient quatre lectures. Le programme suivant spécifie 10 lectures par déclenchement (NRDGS 10) et utilise la commande TARM SGL pour effectuer 8 groupes de 10 lectures (armement multiple). Au total, 80 lectures sont enregistrées en mémoire.

```

10 OUTPUT 722;"TARM HOLD"          ! INTERRUPTION DES LECTURES
20 OUTPUT 722;"DCV 1"              ! TENSION CC, GAMME 1 V
30 OUTPUT 722;"MEM FIFO"           ! VALIDATION DE LA MEMOIRE DE LECTURE,
35                                ! MODE FIFO
40 OUTPUT 722;"TRIG AUTO"          ! DECLENCHEMENT AUTOMATIQUE
50 OUTPUT 722;"NRDGS 10,AUTO"      ! 10 LECTURES/DECLENCHEMENT,
55                                ! ECHANTILLONNAGE AUTOMATIQUE
60 OUTPUT 722;"TARM SGL,8"         ! 8 ARMEMENTS DE DECLENCHEMENT
70 END

```

Les lectures enregistrées peuvent être rappelées par leur numéro respectif (1 à 80) ou par leur numéro d'enregistrement/lecture (exemple: la 3ème lecture de l'enregistrement 2 correspond à la lecture 13). Le programme suivant par exemple appelle et imprime la lecture numéro 50 (la 31ème lecture prise par le programme ci-dessus).

```

10 OUTPUT 722;"RMEM 50"           ! RAPPEL DE LA LECTURE No 50
20 ENTER 722;A                    ! ENTRE LA LECTURE
30 PRINT A                        ! IMPRESSION DE LA LECTURE
40 END

```

Le programme suivant utilise le paramètre “*first*” et le paramètre “*count*” pour appeler et imprimer les lectures 12 à 17.

```

10 OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A 1
20 DIM Rdgs(6)                  ! DIMENSIONNE LE TABLEAU POUR 6
30 OUTPUT 722;"RMEM 12,6"       ! RAPPEL DE 6 LECTURES EN
35                               ! LA LECTURE 112
40 ENTER 722;Rdgs(*)            ! ENTRE LES LECTURES
50 PRINT Rdgs(*)                ! IMPRESSION DES LECTURES
60 END

```

Vous pouvez également utiliser le numéro d'enregistrement pour rappeler des lectures. Le multimètre affecte le numéro d'enregistrement le plus bas (1) à l'enregistrement le plus récent, et le numéro le plus élevé à l'enregistrement le plus ancien. Le programme suivant rappelle la 3ème et la 4ème lectures de l'enregistrement numéro 6 (il s'agit dans ce cas des lectures #53 et 54 respectivement).

```

10 OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A 1
20 DIM Rdgs(2)                  ! DIMENSIONNE LE TABLEAU POUR 2
30 OUTPUT 722;"RMEM 3,2,6"     ! RAPPEL DES 3ème ET 4ème LECTURES
35                               ! L'ENREGISTREMENT #6
40 ENTER 722;Rdgs(*)            ! ENTRE LES LECTURES
50 PRINT Rdgs(*)                ! IMPRESSION DES LECTURES
60 END

```

Quand vous exécutez RMEM à partir du panneau avant, après avoir appelé une lecture par son numéro, vous pouvez faire défiler sur l'affichage les autres lectures enregistrées en mémoire à l'aide des touches fléchées vers le haut ou vers le bas. (La commande RMEM est la seule méthode dont vous disposez pour appeler des lectures enregistrées en mémoire à partir du panneau avant).

Lecture implicite

Lorsque le contrôleur demande des données au multimètre et que sa mémoire-tampon de sortie est vide et sa mémoire de lecture validée, une lecture est extraite de la mémoire, placée dans la mémoire-tampon de sortie puis transmise au contrôleur. C'est la méthode dite de “lecture implicite”. A la différence de la commande RMEM, la lecture implicite supprime les lectures de la

mémoire. En mode LIFO, c'est la lecture la plus récente qui est rappelée; en mode FIFO, c'est la plus ancienne. Le programme suivant effectue 200 lectures, les place en mémoire de lecture et utilise la méthode de lecture implicite pour transmettre les lectures au contrôleur.

```

10 OPTION BASE 1           ! BORNE INFERIEURE DU TABLEAU A1
20 DIM Rdgs(200)           ! DIMENSIONNE LE TABLEAU PO.B 200
25                           ! LECTURES
30 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION : TARM AUTO, TRIG
35                           ! SYN, DCV AUTORANGE
40 OUTPUT 722;"NRDGS 200,AUTO" ! 200 LECTURES/DECLenchement,
45                           ! ECHANTILLONNAGE AUTO
50 OUTPUT 722;"MEM FIFO"    ! VALIDATION DE LA MEMOIRE DE LECTURE,
55                           ! MODE FIFO
60 OUTPUT 722;"TRIG SGL"    ! DECLenchement DES LECTURES
70 PAUSE
80 ENTER 722;Rdgs(*)        ! ENTRE LES LECTURES
90 PRINT Rdgs(*)            ! IMPRESSION DES LECTURES
100 END

```

Transfert des lectures par le bus GPIB

Cette partie décrit les formats de sortie des lectures et explique comment transférer des lectures du multimètre au contrôleur.

Formats de sortie

Le multimètre dirige les lectures vers la mémoire-tampon de sortie GPIB à chaque fois qu'elles sont effectuées et que la mémoire de lecture est invalidée (commande MEM OFF). (Dans les états de mise sous tension, RESET et tous les états PRESET, la mémoire de lecture est invalidée). Les cinq formats de sortie et le nombre d'octets auxquels ils correspondent respectivement sont les suivants:

```
ASCII-- 15 octets par lecture
SINT -- 2 octets par lecture
DINT -- 4 octets par lecture
SREAL-- 4 octets par lecture
DREAL-- 8 octets par lecture
```

- **ASCII** - C'est le format de sortie le plus utilisé car il n'a pas de facteur d'échelle et ne requiert aucune conversion de données par le contrôleur. Comme ce format est celui qui utilise le plus d'octets par lecture, il est conseillé de ne l'utiliser que lorsque la vitesse de mesure n'est pas critique.

REMARQUE

Lorsque vous utilisez le format ASCII, deux octets supplémentaires sont requis pour la séquence de fin de ligne “retour chariot” et “saut de ligne” (cr, lf). Cette séquence n'est utilisée que dans le format ASCII et termine normalement chaque sortie de lecture au format ASCII. Toutefois, lorsque vous rappelez plusieurs lectures au format ASCII de la mémoire de lecture à l'aide de la commande RMEM, le multimètre place une virgule (1 octet) entre chaque lecture. Dans ce cas, la séquence cr, lf n'apparaît qu'une seule fois, après la dernière lecture du groupe rappelée. Les virgules ne sont pas utilisées lorsque les lectures sont directement transmises par le bus (mémoire de lecture invalidée), lorsque les lectures sont rappelées “implicitement” ou lorsqu'elles utilisent un autre format de sortie que le format ASCII.

- **Entier simple (SINT) ou entier long (DINT)** - Utilisez le format SINT pour les mesures à basse résolution (3,5 ou 4,5 chiffres) et à la vitesse la plus élevée possible sur une gamme fixe (fonction de changement de gamme automatique

invalidée). (Comme le format SINT n'utilise que 2 octets par lecture, le transfert des lectures au format SINT par le bus GPIB sera plus rapide que sous n'importe quel autre format). Utilisez le format DINT pour les mesures à haute résolution (5,5 chiffres ou plus) et à la vitesse la plus élevée possible sur une gamme fixe.

REMARQUE

Avec les formats de mémoire/de sortie SINT ou DINT, le multimètre applique un facteur d'échelle aux lectures. Ce facteur dépend de la fonction de mesure, de la gamme, de la configuration du convertisseur A/N, et des fonctions mathématiques validées. Les formats SINT et DINT ne sont pas conseillés pour les mesures de fréquences ou de périodes; lorsqu'une opération mathématique (en temps réel ou après traitement) est validée (à l'exception de STAT ou de PFAIL); et enfin lorsque la fonction de changement de gamme automatique est validée.

- **Réel simple (SREAL) ou réel long (DREAL)** - A la différence des formats SINT et DINT, aucun facteur d'échelle ne s'applique sur les mesures enregistrées sous ces formats qui peuvent être utilisés quelle que soit la fonction de mesure et/ou la configuration du multimètre. (Ces formats sont d'ailleurs recommandés pour les mesures utilisant la fonction de changement de gamme automatique et/ou lorsqu'une fonction mathématique est validée). En outre, avec le format DREAL, le contrôleur n'a aucune conversion à opérer. Utilisez le format SREAL pour les mesures dont la résolution est $\leq 6,5$ chiffres. Utilisez le format DREAL pour les mesures dont la résolution est $> 6,5$ chiffres.

La commande OFORMA T permet de spécifier le format de sortie des lectures (le format par défaut et de mise sous tension est ASCII). Par exemple, pour sélectionner le format "entier long", envoyez:

OUTPUT 722;"OFORMAT DINT"

Indication de surcharge

Le multimètre indique une condition de surcharge (entrée trop importante pour surcharger la gamme) en générant la plus grande valeur possible en fonction du format spécifié, comme indiqué ci-dessous:

Format SINT: +32767 or -32768 (sans facteur d'échelle)
Format DINT: +2.147483647E+9 ou -2.147483648E+9 (sans facteur d'échelle)
Formats ASCII, SREAL, DREAL: +/-1.0E+38

Fin de transmission

Chaque lecture au format ASCII transmise sur le bus GPIB se termine normalement par un *cr,lf* (retour chariot, saut de ligne). Pour la plupart des contrôleurs, cette séquence équivaut à une fin de transmission. La sortie des lectures sous n'importe quel autre format ne se termine pourtant pas par un *cr,lf*. Dans ce cas, vous devez valider la fonction GPIB EOI (Fin ou Identification) pour indiquer la fin du transfert. Pour plus de détails à ce sujet, voir commande END au [chapitre 6](#).

Utilisation du format de sortie SINT ou DINT

La commande ISCALE? renvoie le facteur d'échelle (au format ASCII) des lectures utilisant le format de sortie SINT ou DINT. (Dès que le contrôleur a extrait le facteur d'échelle, le format de sortie repasse au format SINT ou DINT spécifié). Vous pouvez extraire le facteur d'échelle après que le multimètre ait été configuré mais avant que les mesures ne soient déclenchées ou après que toutes les mesures aient été effectuées et transmises au contrôleur. (Si la mémoire-tampon de sortie contient une lecture lorsque la commande d'interrogation ISCALE? est exécutée, la lecture sera "écrasée" (effacée) par le facteur d'échelle).

Exemple SINT

Le programme suivant transmet 10 lectures au format SINT, extrait le facteur d'échelle et multiplie chaque lecture par le facteur d'échelle. Les lectures sont transmises au contrôleur à l'aide de la commande TRANSFER (commande spécifique aux contrôleurs HP 200/300 utilisant le langage BASIC HP). La commande TRANSFER est la méthode de transfert la plus rapide, surtout lorsqu'elle est utilisée avec l'interface GPIB à accès direct à la mémoire (DMA). Il est conseillé de l'utiliser à chaque fois que la vitesse de mesure/transfert est importante.

```
10 OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Num_readings         ! DECLARATION DE LA VARIABLE
30 INTEGER Int_rdgs (1: 10) BUFFER ! CREATION DU TABLEAU DES ENTIERS
35                               ! EN MEMOIRE-TAMPON
40 REAL Rdgs(1:10)              ! CREATION DU TABLEAU DES REELS
50 Num_readings=10              ! NOMBRE DE LECTURES = 10
60 ASSIGN @Dvm TO 722           ! AFFECTATION DE L'ADRESSE DU MULTIMETRE
70 ASSIGN @Int_rdgs TO BUFFER Int_rdgs(*) ! AFFECTATION DU NOM
```

```

75                                     ! D'ACCES DE LA MEMOIRE-TAMPON
80 OUTPUT @Dvm;"PRESET NORM;OFORMAT SINT;NPLC 0;NRDGS";Num_readings
85 ! TARM AUTO, TRIG SYN, FORMAT DE SORTIE SINT, TEMPS
87 ! D'INTEGRATION MIN.
90 TRANSFER @Dvm TO @Int_rdgs;WAIT ! EVENEMENT SYN, TRANSFERT DES
92 ! LECTURES DANS LE TABLEAU DES ENTIERS; PAS DE CONVERSION DE
95 ! DONNEES REQUISES PUISQUE LE FORMAT INTEGER DE L'ORDINATEUR EST
97 ! IDENTIQUE A SINT (MAIS TABLEAUX DES ENTIERS REQUIS)
100 OUTPUT @Dvm;"ISCALE?"      ! INTERROGATION DU FACTEUR D'ECHELLE POUR
102                                ! LE FORMAT SINT
110 ENTER @Dvm;S                ! LECTURE DU FACTEUR D'ECHELLE
120 FOR I=1 TO Num_readings
130 Rdgs(I)=Int_rdgs(I)        ! CONVERSION DE CHAQUE LECTURE DU FORMAT
135 ! ENTIER AU FORMAT REEL{OBLIGATOIRE POUR EVITER UN
138 ! DEPASSEMENT ENTIER SUR LA LIGNE SUIVANTE)
140 R=ABS(Rdgs(I))             ! UTILISATION DE LA VALEUR ABSOLUE POUR
142                                ! VERIFIER SURCHARGE
150 IF R>=32767 THEN PRINT "OVL" ! SI SURCHARGE, IMPRESSION D'UN
152                                ! MESSAGE
160 Rdgs (I) =Rdgs (I) *S      ! MULTIPLICATION DE LA LECTURE PAR LE
162                                ! FACTEUR D'ECHELLE
170 Rdgs(I)=DROUND(Rdgs(I),4) ! VALEUR ARRONDIE A 4 CHIFFRES
180 NEXT I
190 END

```

Exemple DINT

L'exemple suivant est identique au précédent à part qu'il effectue 50 lectures en place de 10 et les transmet à l'ordinateur en utilisant le format DINT.

```

100OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Num_readings,I,J,K ! DECLARATION DES VARIABLES
30 Num_readings= 50             ! NOMBRE DE LECTURES = 50
40 ALLOCATE REAL Rdgs(1:Num_readings) ! CREATION D'UN TABLEAU POUR
42                                ! LES LECTURES
50 ASSIGN @Dvm TO 722           ! AFFECTATION DE L'ADRESSE DU MULTIMETRE
60 ASSIGN @Buffer TO BUFFER [4*Num_readings] ! AFFECTATION DU NOM
65                                ! D'ACCES DE LA MEMOIRE-TAMPON
70 OUTPUT @Dvm;"•PRESET NORM;RANGE 10;OFORMAT DINT;NRDGS •;Num_readings

```

```

75 ! TARM AUTO, TRIG SYN, DCV GAMME 10 V, FORMAT DE SORTIE DINT, 50
77 ! LECTURES,AUTO
80 TRANSFER @Dvm TO @Buffer;WAIT !EVENEMENT SYN,TRANSFERT DES LECTURES
90 OUTPUT @Dvm;"ISCALE?          ! INTERROGATION DU FACTEUR D'ECHELLE POUR
92                                ! LE FORMAT DINT
100 ENTER @Dvm;S                  ! LECTURE DU FACTEUR D'ECHELLE
110 FOR I=1 TO Num_readings
120 ENTER @Buffer USING "#,W,W";J,K ! METTRE UN MOT DE 16 OCTETS
122 NOTATION COMPLEMENT A 2 DANS CHAQUE VARIABLE J ET K (# = FIN
125 ! D'INSTRUCTION NON REQUISE; W = METTRE DONNEES SOUS FORME
127 ! ENTIER 16 BITS NOTATION COMPLEMENT A 2)
130 Rdgs(I)=(J*65536.+K+65536.*(K<0)) ! CONVERTIR EN NB REEL
140 R=ABS(Rdgs(I))                  ! UTILISATION DE LA VALEUR ABSOLUE POUR
142                                ! VERIFIER SURCHARGE
150 IF R>=2147483647 THEN PRINT "OVLd" ! SI SURCHARGE, IMPRESSION
152                                ! D'UN MESSAGE
160 Rdgs(I)=Rdgs(I)*S              ! APPLICATION DU FACTEUR D'ECHELLE
170 Rdgs(I)=DROUND(Rdgs(I),8) ! ARRONDIT LECTURE CONVERTIE
180 PRINT Rdgs (I)                 ! IMPRESSION DES LECTURES
190 NEXT I
200 END

```

Utilisation du format de sortie SREAL

Le programme suivant montre comment convertir 10 lectures au format SREAL.

```

10 OPTION BASE 1                  ! BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Num_readings          ! DECLARATION DE LA VARIABLE
30 Num_readings=10               ! NOMBRE DE LECTURES = 10
40 ALLOCATE REAL                 ! CREATION D'UN TABLEAU POUR
42                               ! LES LECTURES
50 ASSIGN @Dvm TO 722            ! AFFECTATION DE L'ADRESSE DU
60 ASSIGN @Buffer TO BUFFER      ! AFFECTATION DU NOM
65                               ! D'ACCES DE LA MEMOIRE-TAMPON
70 OUTPUT @Dvm;"PRESET NORM;OFORMAT SREAL;NRDGS";Num_readings
75 !TRIG SYN, FORMAT DE SORTIE SREAL, 1 PLC, DCV GAMME AUTO, 10
77                               ! LECTURES
80 TRANSFER @Dvm TO @Buffer;WAIT ! EVENEMENT SYN, TRANSFERT DES

```

```

82                                     ! LECTURES
90 FOR I=1 TO Num_readings
100 ENTER @Buffer USING              ! METTRE UN OCTET DE 8 BITS
102 ! DANS CHAQUE VARIABLE, (# = FIN D'INSTRUCTION NON REQUISE; B
105 ! = = LIRE UN OCTET DE 8 BITS ET L'INTERPRETER COMME UN ENTIER
107 ! ENTRE 0 ET 255)
110 S=1                              ! CONVERTIT LECTURE A PARTIR DE
120 IF A>127 THEN S=-1                ! CONVERTIT LECTURE A PARTIR DE
130 IF A>127 THEN A=A-128            ! CONVERTIT LECTURE A PARTIR DE
140 A=A*2- 127                       ! CONVERTIT LECTURE A PARTIR DE
150 IF B>127 THEN A=A+1              ! CONVERTIT LECTURE A PARTIR DE
160 IF B<=127 THEN B=B+128          ! CONVERTIT LECTURE A PARTIR DE
170                                  ! CONVERTIT LECTURE A
175                                  ! PARTIR DE SREAL
180 Rdgs(I)=DROUND(Rdgs(I),7)        ! ARRONDIT LA LECTURE A 7
182 ! CHIFFRES; OBLIGATOIRE AVEC SREAL POUR S'ASSURER QUE LES
185 ! VALEURS DE SURCHARGE SERONT ARRONDIES A 1.E+38 (SANS
187 ! ARRONDI, LA VALEUR PEUT ETRE LEGEREMENT INFERIEURE)
190 IF ABS(Rdgs(I))=1.E+38 THEN      ! EN CAS DE SURCHARGE :
200 PRINT "Overload Occurred"       ! IMPRIME "SURCHARGE"
210 ELSE                             ! SI PAS DE SURCHARGE :
220 PRINT Rdgs(I)                   ! IMPRIME LES LECTURES
230 END IF
240 NEXT I
250 END

```

Utilisation du format de sortie DREAL

Le programme suivant utilise le format de sortie DREAL. Vous remarquerez qu'aucune conversion n'est nécessaire avec ce format qui utilise la même représentation de données que le contrôleur (8 octets/mot).

```

10 OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A1
20 REAL Rdgs(1:10) BUFFER      ! CREATION DU TABLEAU DES REELS EN
25                             ! EN MEMOIRE-TAMPON
30 ASSIGN @Dvm TO 722          ! AFFECTATION DE L'ADRESSE DU MULTIMETRE
40 ASSIGN @Rdgs TO BUFFER Rdgs(*) ! AFFECTATION DU NOM D'ACCES DE
45                             ! LA MEMOIRE-TAMPON
50 OUTPUT @Dvm;1'PRESET NORM;NPLC 10;OFORMAT DREAL;NRDGS 10"
55 ! TRIG SYN, 10 PLC, DCV GAMME AUTO,FORMAT DE SORTIE DREAL, 10
57 ! LECTURES/DECLenchement
60 TRANSFER @Dvm TO @Rdgs;WAIT ! EVENEMENT SYN, TRANSFERT DES LECTURES
70 FOR I=1 TO 10
80 IF ABS(Rdgs(I))=1.E+38 THEN ! EN CAS DE SURCHARGE :
90 PRINT "OVERLOAD OCCURRED" ! IMPRIME "SURCHARGE"
100 ELSE                       ! SI PAS DE SURCHARGE :
110 Rdgs(I)=DROUND(Rdgs(I),8) ! ARRONDIT LES MESURES
120 PRINT Rdgs(I)              ! IMPRIME LES LECTURES
130 END IF
140 NEXT I
150 END

```

Le programme précédent utilise l'instruction TRANSFER pour extraire les lectures du multimètre. Le programme suivant utilise l'instruction ENTER pour transférer les lectures sur l'ordinateur en utilisant le format DREAL. L'instruction ENTER est plus simple d'emploi puisqu'elle ne requiert aucun nom d'accès mais elle est plus lente que l'instruction TRANSFER. En outre, avec l'instruction ENTER vous devez utiliser la commande FORMAT OFF pour que le contrôleur utilise sa structure de données interne au lieu du format ASCII.

```

10 OPTION BASE 1                ! BORNE INFERIEURE OU TABLEAU A1
20 Num_readings=20              ! NOMBRE DE LECTURES = 20
30 ALLOCATE REAL                ! CREATION D'UN TABLEAU POUR
32                             ! LES LECTURES
40 ASSIGN @Dvm TO 722          ! AFFECTATION DE L'ADRESSE DU

```



```

50 OUTPUT @Dvm;"PRESET NORM;OFORMAT DREAL;NPLC 10;NRDGS";Num_readings
55 ! TRIG SYN, DCV Gamme auto, FORMAT DE SORTIE DREAL, 10 PLC, 20
57 ! LECTURES/DECLenchement
60 ASSIGN @Dvm;FORMAT OFF           ! STRUCTURE DE DONNEES = 8 OCTETS/
70 FOR I=1 TO Num_readings
80 ENTER @Dvm;Rdgs(I)               ! TRANSFERER CHAQUE LECTURE
90 IF ABS(Rdgs(I))=1.E+38 THEN       ! EN CAS DE SURCHARGE :
100 PRINT "OVERLOAD OCCURRED"!      ! IMPRIME "SURCHARGE"
110 ELSE                             ! SI PAS DE SURCHARGE :
120 Rdgs(I)=DROUND(Rdgs(I),8)       ! ARRONDIT LES MESURES A 8
130 PRINT Rdgs(I)                   ! IMPRIME LES LECTURES
140 END IF
150 NEXT I
160 END

```

Augmentation de la vitesse de lecture

Cette partie traite du mode grande vitesse du multimètre et des facteurs qui affectent la vitesse de lecture. Elle renferme des exemples de programme qui montrent comment accroître la vitesse de lecture et effectuer des transferts à grande vitesse de la mémoire de lecture au contrôleur ou encore comment déterminer la vitesse de lecture.

Mode grande vitesse

Pour les mesures de tension continue, de courant continu, de résistance 2 et 4 fils et les mesures directes ou sous-échantillonnées,^[1] le multimètre adopte le mode grande vitesse lorsque les lectures sont initialisées, que le temps d'intégration est inférieur à 10 PLC (périodes d'alimentation secteur) et que les commandes suivantes ont été exécutées:

```

ARANGE OFF
DISP OFF
MATH OFF
MFORMAT SINT or DINT (uniquement lorsque la mémoire de lecture est
validée)
OFORMAT SINT or DINT (uniquement lorsque la mémoire de lecture est
invalidée)

```

En mode grande vitesse, le multimètre se consacre uniquement aux mesures. Cela signifie qu'il ne traitera aucune commande tant que les lectures spécifiées ne sont pas terminées. Lorsque les lectures sont directement transférées dans la mémoire-tampon de sortie, le multimètre attend que chaque lecture soit extraite de la mémoire-tampon de sortie avant d'y placer la suivante. Ainsi, aucune lecture ne risque d'être perdue à cause de limites de vitesse imposées par le bus/contrôleur. (Quand le multimètre n'est pas en mode grande vitesse, il efface toute lecture présente dans la mémoire-tampon de sortie lorsqu'une nouvelle lecture est disponible).

En mode grande vitesse, si la mémoire de lecture est validée en mode d'enregistrement FIFO, l'événement d'armement de déclenchement passe à HOLD dès que la mémoire est pleine, ce qui interrompt les lectures et met fin au mode grande vitesse. Après avoir enlevé une ou plusieurs lectures de la mémoire, vous pouvez reprendre les mesures en modifiant l'événement d'armement de

[1] Pour plus de détails sur les mesures directes et sous-échantillonnées, se reporter au [chapitre 5](#).

déclenchement (commande TARM). En mode LIFO, lorsque la mémoire de lecture est pleine, les anciennes lectures sont remplacées par les nouvelles, que le multimètre soit en mode grande vitesse ou pas.

REMARQUE

En mode grande vitesse, la mémoire-tampon d'entrée est temporairement invalidée pendant les lectures. Si d'autre part, END ALWAYS a été spécifié (mode de la commande GPIB EO/), le mode EOI passe à END ON pendant les lectures. Une fois les lectures terminées, la mémoire-tampon d'entrée et le mode EOI reprennent leur précédent état ou valeur.

En mode grande vitesse, le multimètre ne répond qu'à une seule commande Device Clear (Libérer appareil). Si pour une quelconque raison, vous devez invalider le mode grande vitesse, envoyez:

CLEAR 722

La commande CLEAR suspend les mesures, ce qui invalide automatiquement le mode grande vitesse. Pour plus de détails sur la commande GPIB CLEAR (Libérer), se reporter à l'[annexe B](#).

Configuration pour lectures rapides

La commande PRESET FAST exécute une série de commandes qui configurent le multimètre pour des lectures rapides. De plus, la vitesse de lecture est affectée par le temps d'intégration et/ou la résolution; par le mode de déclenchement; par le retard spécifié; par la largeur de bande alternative (pour les mesures alternatives uniquement) et par la compensation de décalage (pour les mesures de résistance uniquement).

REMARQUE

Outre les commandes décrites dans cette partie, la commande DEFEAT peut être utilisée pour accélérer le débit par invalidation de l'algorithme de protection des entrées du multimètre et de certains algorithmes de vérification de syntaxe et d'erreur. Une fois ces algorithmes invalidés, le multimètre se reconfigure pour une nouvelle mesure plus rapidement. Pour plus de détails sur la commande DEFEAT, se reporter au [chapitre 6](#) (lire également l'AVERTISSEMENT relatif à l'utilisation de cette commande).

Commande PRESET FAST

La commande PRESET FAST invalide de nombreuses fonctions qui ralentissent la vitesse de lecture et configure le multimètre pour des transferts de lecture rapides vers la mémoire et le bus GPIB. Le [Tableau 4-3](#) indique les commandes exécutées par PRESET FAST et la raison pour laquelle elles sont exécutées.

Tableau 4-3 Commandes exécutées par PRESET FAST

Commande	Raison
DCV 10	Sélectionne les mesures de tension continue dans la gamme 10 V, ce qui invalide la fonction de changement de gamme automatique. Normalement, cette fonction échantillonne l'entrée avant chaque lecture, ce qui rallonge d'autant le temps de mesure. L'inconvénient d'une gamme fixe est une résolution moindre pour les signaux inférieurs à 10% de la pleine échelle et la possibilité d'une condition de surcharge pour les lectures hors gamme.
AZERO OFF	Lorsque la fonction d'auto-zéro est validée, une mesure de zéro est effectuée après chaque lecture (pour les mesures continues uniquement), ce qui accroît la durée de chacune d'elles.
DISP OFF	Le temps requis par le multimètre pour réactualiser son affichage ralentit la vitesse des lectures.
MATH OFF	Toute opération mathématique en temps réel validée ralentit la vitesse de lecture. Si vous devez effectuer des opérations mathématiques sur des lectures, utilisez les fonctions mathématiques de post-traitement (commande MMATHJ). Pour plus de détails sur cette commande, voir Opérations mathématiques plus loin dans ce chapitre.

Tableau 4-3 Commandes exécutées par PRESET FAST

Commande	Raison
MFORMAT DINT	Les lectures sont fournies par le convertisseur A/N au format SINT ou DINT (le format utilisé dépend de la résolution spécifiée pour la mesure; ^[a] dans la configuration sélectionnée par PRESET FAST, le convertisseur A/N utilise le format DINT). La méthode la plus rapide pour transférer des lectures dans la mémoire de lecture consiste à utiliser le format mémoire (MFORMAT) qui correspond à celui du convertisseur A/N pour éliminer les temps de conversion. (Les formats SINT et DINT ont été présentés plus haut dans ce chapitre. Voir Formats de lecture .
OFORMAT DINT	Les lectures sont fournies par le convertisseur A/N au format SINT ou DINT (le format utilisé dépend de la résolution spécifiée pour la mesure; ^[a] dans la configuration sélectionnée par PRESET FAST, le convertisseur A/N utilise le format DINT). La méthode la plus rapide pour transférer des lectures dans la mémoire-tampon de sortie consiste à utiliser le format de sortie (OFORMAT) qui correspond à celui du convertisseur A/N pour éliminer les temps de conversion. De plus, si le format de sortie correspond au format sous lequel les lectures sont enregistrées en mémoire, aucune conversion n'est requise pour rappeler les lectures de la mémoire. (Les formats SINT et DINT ont été présentés plus haut dans ce chapitre. Voir Formats de lecture .

[a] Pour les numérisations sur échantillons directs, le format utilisé dépend de l'amplitude du signal d'entrée. Pour plus de détails à ce sujet, se reporter au [chapitre 5](#).

Temps d'intégration et résolution

Mesures continues, mesures de résistance et mesures alternatives analogiques : Le temps d'intégration spécifié et/ou la résolution ont une répercussion directe sur la vitesse de lecture pour les mesures de tension continue, de courant continu, de résistance 2- ou 4-fils, de courant alternatif ou alternatif+ continu et de tension alternative ou alternative + continue (effectuées à l'aide de la méthode analogique SETACV ANA uniquement). Les spécifications figurant dans l'[annexe A](#) indiquent les vitesses de lectures sélectionnées pour chacune de ces mesures, à partir du temps d'intégration.

Mesures de tension alternative échantillonnées: Pour les mesures de tension alternative ou alternative + continue effectuées à l'aide de la méthode d'échantillonnage (commande SETACV SYNC ou SETACV RND), le temps d'intégration est fixe et ne peut pas être modifié. Pour ces mesures, la résolution spécifiée a une répercussion directe sur la vitesse des mesures. Les spécifications

figurant dans l'**annexe A** indiquent les vitesses de lectures sélectionnées pour les mesures alternatives à échantillonnage, à partir de la résolution spécifiée.

Mesures de fréquence ou de période: Le temps d'intégration n'affecte pas les mesures de fréquence ou de période. Pour ces mesures, la résolution spécifiée (qui sélectionne en même temps de temps de porte) a une répercussion directe sur la vitesse des lectures. Les spécifications figurant dans l'**annexe A** indiquent les vitesses de lectures sélectionnées pour les mesures de fréquence ou de période, à partir de la résolution spécifiée.

Configuration du déclenchement

Pour que les déclenchements soient les plus rapides possibles, définissez les événements d'armement, de déclenchement et d'échantillonnage en mode AUTO. Vous pouvez également utiliser l'événement d'échantillonnage TIMER (ou la commande SWEEP). A condition que vous ne génériez pas une erreur 1 RIGGER TOO FAST (Déclenchement trop rapide), la vitesse de lecture est l'inverse de l'intervalle spécifié par TIMER ou SWEEP.

Valeur de retard

En mode d'utilisation normal, le multimètre détermine automatiquement une valeur de retard (retard par défaut) à partir de la fonction de mesure, de la gamme, de la résolution courantes et pour les mesures alternatives, il tient également compte de la largeur de bande ca. Cette valeur de retard correspond en fait à un temps d'établissement inséré avant la première lecture pour garantir la précision des mesures. Ce retard influe beaucoup sur la vitesse des lectures pour les mesures alternatives analogiques et peu pour les mesures de tension alternative échantillonnées ou les mesures continues. Pour les mesures alternatives analogiques, vous pouvez améliorer la vitesse de lecture en spécifiant une valeur de retard inférieure à la valeur par défaut. Le temps d'établissement qui en résultera peut toutefois produire des mesures imprécises.

Largeur de bande CA

Pour des mesures alternatives les plus rapides possibles, spécifiez une largeur de bande (commande ACBAND) qui correspond aux composantes de fréquence du signal d'entrée. Les spécifications figurant dans l'**annexe A** indiquent les vitesses de lectures sélectionnées pour les mesures alternatives, à partir des composantes de fréquence du signal d'entrée.

Compensation de décalage

Pour les mesures de résistance 2- ou 4-fils avec compensation de décalage, la tension de décalage est mesurée avant chaque lecture. Le temps de mesure est plus court lorsque la fonction de compensation de décalage est invalidée (commande OCOMP OFF).

Exemple DCV à grande vitesse

Le programme suivant mesure des tensions continues à la vitesse maximale (>100k lectures par seconde). Les lectures sont enregistrées en mémoire de lecture.

```

10 OUTPUT 722;"PRESET FAST"           ! TENSION CONTINUE, GAMME 10V,
15                                     ! ARMEMENT SYN, DECLenchement AUTO
20 OUTPUT 722;"APER 1.4E-6"           ! PLUS LONG TEMPS D'INTEGRATION
25                                     ! POSSIBLE POUR >100k LECTURES/S
30 OUTPUT 722;"MFORMAT SINT"          ! FORMAT DE MEMOIRE: ENTIER SIMPLE
40 OUTPUT 722;"MEM FIFO"              ! VALIDE LA MEMOIRE CE LECTURE
50 OUTPUT 722;"NRDGS 10000,AUTO"      ! 10000 LECTURES/OECLenchement,
55                                     ! EVENEMENT D'ECHANTILLONNAGE AUTO
60 OUTPUT 722;"TARM SGL"              ! DECLenche LES LECTURES
70 END

```

Exemple OHM (ou OHMF) à grande vitesse

Le programme suivant mesure des résistances 2 fils à la vitesse maximale (>100k lectures par seconde). Ce programme peut être adapté pour les mesures de résistance 4 fils en remplaçant la commande OHM: par la commande OHMF, à la ligne 50.

```

10 OUTPUT 722;"PRESET FAST"!         ! TENSION CONTINUE, GAMME 10V,
15                                     ! ARMEMENT SYN, DECLenchement AUTO
20 OUTPUT 722;"APER 1.4E-6"         ! PLUS LONG TEMPS D'INTEGRATION

```

```

25                                     ! POSSIBLE POUR >100k LECTURES/S
30 OUTPUT 722;"MFORMAT SINT"         ! FORMAT DE MEMOIRE: ENTIER SIMPLE
40 OUTPUT 722;"MEM FIFO"             ! VALIDE LA MEMOIRE DE LECTURE
50 OUTPUT 722;"OHM 100E3"            ! RESISTANCE 2-FILS, GAMME 100 kΩ
60 OUTPUT 722;"NRDGS 10000,AUTO"     ! 10000 LECTURES/DECLenchement,
65                                     ! EVENEMENT D'ECHANTILLONNAGE AUTO
70 OUTPUT 722;"TARM SGL"             ! DECLenche LES LECTURES
80 END

```

Exemple DCI à grande vitesse

Le programme suivant mesure des courants continus à la vitesse maximale.

```

10 OUTPUT 722;"PRESET FAST"          ! TENSION CONTINUE, GAMME 10V,
15                                     ! ARMEMENT SYN, DECLenchement AUTO
20 OUTPUT 722;"APER 1.4E-6"I        ! PLUS LONG TEMPS D'INTEGRATION
25                                     ! POSSIBLE POUR VITESSE DE LECTURE
27                                     ! MAXIMALE
30 OUTPUT 722;"MFORMAT SINT"         ! FORMAT DE MEMOIRE: ENTIER SIMPLE
40 OUTPUT 722;"MEM FIFO"             ! VALIDE LA MEMOIRE DE LECTURE
50 OUTPUT 722;"DCI 100E-3"!         ! COURANT CONTINU, GAMME 100 mA
60 OUTPUT 722;"NRDGS 5000 AUTO"     ! 5000 LECTURES/DECLenchement,
65                                     ! EVENEMENT D'ECHANTILLONNAGE AUTO
70 OUTPUT 722;"TARM SGL"             ! DECLenche LES LECTURES
80 END

```

Exemple ACV (ou ACDCV), méthode synchrone, rapide

Le programme suivant mesure des tensions alternatives (méthode synchrone), à la vitesse maximale (environ 10 lectures par seconde). Ce programme peut être adapté pour les mesures de tensions alternatives + continues en remplaçant la commande ACY par la commande ACDCV, à la ligne 50.

```

10 OUTPUT 722;"PRESET FAST"          ! ARMEMENT SYN, DECLenchement AUTO
20 OUTPUT 722;"MFORMAT SINT"         ! FORMAT DE MEMOIRE: ENTIER SIMPLE
30 OUTPUT 722;"MEM FIFO"             ! VALIDE LA MEMOIRE DE LECTURE
40 OUTPUT 722;"SETACV SYNC"          ! METHODE DE MESURE CA SYNCHRONE
50 OUTPUT 722;"ACV 10,2"             ! VOLTS CA, GAMME 10 V, 2% RESOLUTION

```



```

60 OUTPUT 722;"ACBAND 5E3,8E3" ! SIGNAL ENTRE 5 ET 8 kHz
70 OUTPUT 722;"NRDGS 20, AUTO" ! 20 LECTURES/DECLenchement,
75                                ! EVENEMENT D'ECHANTILLONNAGE AUTO
80 OUTPUT 722;"TARM SGL"        ! DECLenche LES LECTURES
90 END

```

Exemple ACV (ou ACDCV), méthode aléatoire, rapide

Le programme suivant mesure des tensions alternatives (méthode aléatoire), à la vitesse maximale (environ 45 lectures par seconde). Ce programme peut être adapté pour les mesures de tensions alternatives + continues en remplaçant la commande ACV par la commande ACDCV, à la ligne 50.

```

10 OUTPUT 722;"PRESET FAST"      ! ARMEMENT SYN, DECLenchement AUTO
20 OUTPUT 722;"MFORMAT SINT"     ! FORMAT DE MEMOIRE: ENTIER SIMPLE
30 OUTPUT 722;"MEM FIFO"         ! VALIDE LA MEMOIRE DE LECTURE
40 OUTPUT 722;"SETACV RNDM"      ! METHODE DE MESURE CA ALEATOIRE
50 OUTPUT 722;"ACV 10 6"         ! VOLTS CA, GAMME 10 V, 6% RESOLUTION
60 OUTPUT 722;"ACBAND 10E3,20E3" ! SIGNAL ENTRE 10 ET 20 kHz
70 OUTPUT 722;"NRDGS 100, AUTO"  ! 100 LECTURES/DECLenchement,
75                                ! EVENEMENT D'ECHANTILLONNAGE AUTO
80 OUTPUT 722;"TARM SGL"        ! DECLenche LES LECTURES
90 END

```

Exemple ACV (ou ACDCV), méthode analogique, rapide

Le programme suivant mesure des tensions alternatives (méthode analogique), à la vitesse maximale. Ce programme utilise la valeur de retard par défaut. Vous pouvez améliorer la vitesse de lecture en spécifiant une valeur de retard inférieure à cette valeur par défaut. Le temps d'établissement qui en résultera peut toutefois produire des mesures imprécises. Vous pouvez également obtenir des vitesses de lecture plus rapides non spécifiées en réduisant le temps d'intégration à la ligne 60. Ce programme peut être adapté pour les mesures de tensions alternatives + continues en remplaçant la commande ACV par la commande ACDCV, à la ligne 50.

```

10 OUTPUT 722;"PRESET FAST"      ! ARMEMENT SYN, DECLenchement AUTO
20 OUTPUT 722;"MFORMAT SINT"     ! FORMAT DE MEMOIRE: ENTIER SIMPLE
30 OUTPUT 722;"MEM FIFO"         ! VALIDE LA MEMOIRE DE LECTURE,

```

```

35                                     ! MODE FIFO
40 OUTPUT 722;"SETACV ANA"           ! METHODE DE MESURE CA ANALOGIQUE
50 OUTPUT 722;"ACV 10"               ! VOLTS CA, GAMME 10 V
60 OUTPUT 722;"NPLC 0.1"            ! TEMPS D'INTEGRATION: 0,1
65                                     ! PERIODE/SECTEUR
70 OUTPUT 722;"ACBAND 10E3,20E3"    ! SIGNAL ENTRE 10 ET 20 kHz
80 OUTPUT 722;"NRDGS 100, AUTO"     ! 100 LECTURES/DECLenchement,
85                                     ! EVENEMENT D'ECHANTILLONNAGE AUTO
90 OUTPUT 722;"TARM SGL"            ! DECLenche LES LECTURES
100 END

```

Exemple ACI (ou ACDCl) rapide

Le programme suivant mesure des courants alternatif, à la vitesse maximale. Ce programme utilise la valeur de retard par défaut. Vous pouvez améliorer la vitesse de lecture en spécifiant une valeur de retard inférieure à cette valeur par défaut. Le temps d'établissement qui en résultera peut toutefois produire des mesures imprécises. Vous pouvez également obtenir des vitesses de lecture plus rapides non spécifiées en réduisant le temps d'intégration à la ligne 50. Ce programme peut être adapté pour les mesures de courants alternatifs + continus en remplaçant la commande ACI par la commande ACDCl, à la ligne 40.

```

10 OUTPUT 722;"PRESET FAST"         ! ARMEMENT SYN, DECLenchement AUTO
20 OUTPUT 722;"MFORMAT SINT"       ! FORMAT DE MEMOIRE: ENTIER SIMPLE
30 OUTPUT 722;"MEM FIFO"           ! VALIDE LA MEMOIRE DE LECTURE,
35                                     ! MODE FIFO
40 OUTPUT 722;"ACI 100E-3"         ! OCURANT CA, GAMME 100 mV
50 OUTPUT 722;"NPLC 0.1"          ! TEMPS C'INTEGRATION: 0,1
55                                     ! PERIODE/SECTEUR
60 OUTPUT 722;"ACBAND 10E3,20E3"   ! SIGNAL ENTRE 10 ET 20 khz
70 OUTPUT 722;"NRDGS 100,AUTO"     ! 100 LECTURES/DECLenchement,
75                                     ! EVENEMENT D'ECHANTILLONNAGE AUTO
80 OUTPUT 722;"TARM SGL"           ! DECLenche LES LECTURES
90 END

```

Exemple FREQ (ou PER) rapide

Le programme suivant mesure des fréquences à grande vitesse. Ce programme peut être adapté pour mesurer des périodes en remplaçant la commande `FREQ` par la commande `PER`, à la ligne 40.

```

10 OUTPUT 722;"PRESET FAST"           ! ARMEMENT SYN, DECLENCHEMENT AUTO
20 OUTPUT 722;"MFORMAT SREAL"         ! FORMAT DE MEMOIRE: REEL SIMPLE
30 OUTPUT 722;"MEM FIFO"              ! VALIDE LA MEMOIRE DE LECTURE,
35                                     ! MODE FIFO
40 OUTPUT 722;"FREQ 10, .1"           ! FREQUENCE, GAMME 10 V, TEMPS DE
45                                     ! PORTE 100 µs
50 OUTPUT 722;"ACBAND 10E3,20E3"      ! SIGNAL ENTRE 10 ET 20 kHz
60 OUTPUT 722;"NRDGS 100, AUTO"       ! 100 LECTURES/DECLENCHEMENT,
65                                     ! EVENEMENT D'ECHANTILLONNAGE AUTO
70 OUTPUT 722;"TARM SGL"              ! DECLENCHE LES LECTURES
80 END

```

Transfert à grande vitesse par le bus GPIB

Pour obtenir des temps de transfert des lectures vers le contrôleur très courts, spécifiez un format de sortie (commande `OFORMAT`) identique au format utilisé par le convertisseur NN (`SINT` ou `DINT`). Le multimètre n'a ainsi aucune conversion de format à effectuer. Pour des lectures à grande vitesse et basse résolution (3,5 ou 4,5 chiffres) effectuées sur une gamme fixe, utilisez le format de sortie `SINT`. (Comme le format `SINT` n'utilise que 2 octets par lecture, le transfert des lectures au format `SINT` par le bus GPIB sera plus rapide que sous n'importe quel autre format). Utilisez le format `DINT` pour le transfert des mesures à haute résolution (5,5 chiffres ou plus), à la vitesse la plus élevée possible, sur une gamme fixe.

Le multimètre peut effectuer des lectures et les transmettre au contrôleur à la vitesse de $\geq 100k$ lectures à la seconde. Si vous utilisez le format de sortie `SINT` à cette vitesse de lecture, le bus GPIB et le contrôleur doivent être capable de transférer des données à >200 Ko par seconde. Pour ce faire, les ordinateurs HP série 200/300 doivent être équipés d'une carte d'accès direct à la mémoire (DMA). D'autre part, les périphériques susceptibles de ralentir le transfert et les câbles GPIB non utilisés doivent être débranchés du bus pour que la vitesse de transfert maximale puisse être atteinte.

Le programme suivant transmet directement des lectures au contrôleur, le plus rapidement possible. Le multimètre est configuré à sa vitesse de lecture maximale ($>100k$ lectures par seconde) et les lectures sont transmises au format `SINT`. Si le

bus/contrôleur ne peut pas transmettre les données à >200 Ko par seconde, la vitesse de lecture sera ralentie car en mode grande vitesse, le multimètre attend que chaque lecture soit extraite de sa mémoire-tampon de sortie avant d'y placer la suivante. Le programme suivant utilise l'événement d'armement de déclenchement SYN pour déclencher les lectures (TRIG SYN pourrait également être utilisé). En mode grande vitesse, l'événement SYN est primordial car il s'assure que le contrôleur est prêt à recevoir la première lecture générée par le multimètre. L'instruction TRANSFER (ligne 120) satisfait l'événement SYN et constitue le moyen le plus rapide pour transférer des lectures par le bus GPIB, surtout lorsqu'elle est utilisée avec l'interface GPIB à accès direct à la mémoire (DMA).

```

10 OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Num_readings         ! DECLARATION DE LA VARIABLE
30 INTEGER Int_rdgs(1:30000)    BUFFER ! CREATION DU TABLEAU DES
35                               ! ENTIERS EN MEMOIRE-TAMPON
40 REAL Rdgs(1:30000)           ! CREATION DU TABLEAU DES REELS
50 Num_readings=30000           ! NOMBRE DE LECTURES = 30000
60 ASSIGN @Dvm TO 722           ! AFFECTATION DE L'ADRESSE DU MULTIMETRE
70 ASSIGN Int_rdgs TO BUFFER Int_rdgs(*) ! AFFECTATION DU NOM
75                               ! D'ACCES DE LA MEMOIRE-TAMPON
80 OUTPUT @Dvm; "PRESET FAST"    ! ARMEMENT SYN, DECLenchement AUTO,
85                               ! TENSION CONTINUE, GAMME 10 V
90 OUTPUT @Dvm; "APER 1.4E-6"    ! TEMPS D'INTEGRATION 1,4 µs
100 OUTPUT @Dvm; "OFORMAT SINT"! FORMAT DE SORTIE ENTIER SIMPLE
110 OUTPUT @Dvm; "NRDGS"; Num_readings ! 30000 LECTURES/DECLenchement
115 ! ECHANTILLONNAGE AUTO (VALEUR PAR DEFALT)
120 TRANSFER @Dvm TO @Int rdgs;WAIT ! EVENEMENT SYN, TRANSFERT DES
121 ! LECTURES DANS LE TABLEAU DES ENTIERS; PAS DE CONVERSION DE
122 ! DONNEES REQUISES PUISQUE LE FORMAT INTEGER DE L'ORDINATEUR EST
125 ! IDENTIQUE A SINT (MAIS TABLEAUX DES ENTIERS REQUIS)
130 OUTPUT @Dvm; "ISCALE?"       ! INTERROGATION DU FACTEUR D'ECHELLE
140 ENTER @Dvm;S                 ! LECTURE DU FACTEUR D'ECHELLE
150 FOR I=1 TO Num_readings
160 Rdgs(I)=Int_rdgs(I)          ! CONVERSION DE CHAQUE LECTURE DU FORMAT
165 ! ENTIER AU FORMAT REEL(OBLIGATOIRE POUR EVITER UN
167 ! DEPASSEMENT ENTIER SUR LA LIGNE SUIVANTE)
170 R=ABS(Rdgs(I))               ! UTILISATION DE LA VALEUR ABSOLUE POUR
175                               ! VERIFIER SURCHARGE

```

```

180 IF R>=32767 THEN PRINT "OVLD" ! SI SURCHARGE, IMPRESSION D'UN
185                               ! MESSAGE
190 Rdgs(I)=Rdgs(I)*S           ! MULTIPLICATION DE LA LECTURE PAR LE
195                               ! FACTEUR D'ECHELLE
200 Rdgs(I)=OROUND(Rdgs(I),4) ! VALEUR ARRONDIE A 4 CEIFFRES
210 NEXT I
220 END

```

Transfert à grande vitesse à partir de la mémoire

Pour obtenir des temps de transfert des lectures de la mémoire vers le contrôleur très courts, spécifiez un format de mémoire (commande MFORMAT) identique au format de sortie (commande OFORMAT). Le multimètre n'a ainsi aucune conversion de format à effectuer. Pour des lectures à grande vitesse et basse résolution (3,5 ou 4,5 chiffres) effectuées sur une gamme fixe, utilisez le format de sortie SINT. (Comme le format SINT n'utilise que 2 octets par lecture, les lectures enregistrées en mémoire au format SINT seront transférées par le bus GPIB plus rapidement que sous n'importe quel autre format). Utilisez le format DINT pour le transfert des mesures à haute résolution (5,5 chiffres ou plus), à la vitesse la plus élevée possible, sur une gamme fixe. A chaque fois que la fonction de changement de gamme automatique est validée et que la vitesse de transfert est critique, utilisez le format SREAL (pour les lectures de 6,5 chiffres ou moins) ou le format DREAL (pour les lectures de 7,5 ou 8,5 chiffres). L'invalidation de l'affichage et des opérations mathématiques garantira les transferts les plus rapides entre la mémoire de lecture et le contrôleur.

Le programme suivant fournit un exemple de transfert le plus rapide possible entre la mémoire de lecture et le contrôleur. Le programme enregistre 5000 lectures au format SINT en mémoire de lecture. Ces lectures sont ensuite extraites de la mémoire à l'aide de la méthode de "lecture implicite" et transmises au contrôleur (au format SINT) par 1 'instruction TRANSFER (ligne 130). Le contrôleur extrait le facteur d'échelle, multiplie ce facteur par chaque lecture et enregistre les lectures ainsi corrigées dans le tableau *Rdgs*.

```

10 OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A 1
20 REAL Num_readings            ! DECLARATION DE LA VARIABLE
30 INTEGER Int_rdgs (1:5000)    ! CREATION DU TABLEAU DES
35                               ! ENTIERS EN MEMOIRE-TAMPON
40 REAL Rdgs(1:5000)            ! CREATION DU TABLEAU DES REELS POUR LES
42                               ! LECTURES

```

```

50 Num_readings=5000          NOMBRE DE LECTURES = 5000
60 ASSIGN @Dvm TO 722         AFFECTATION DE L'ADRESSE DU MULTIMETRE
70 ASSIGN @Int_rdgs TO BUFFER Int_rdgs(*) ! AFFECTATION DU NOM
75                             ! D'ACCES DE LA MEMOIRE-TAMPON
80 OUTPUT @Dvm;"PRESET FAST;OFORMAT SINT;MFORMAT SINT;MEM FIFO;APER
1.4E-6;NRDGS ";Num_readings ! ARMEMENT SYN, DECLENCHEMENT AUTO,
85 ! LECTURES RAPIDES, FORMAT MEMOIRE/SORTIE ENTIER SIMPLE, 1,4 µs
87 ! TEMPS D'INTEGRATION, 5000 LECTURES/DECLENCHEMENT
90 OUTPUT @Dvm;"TARM SGL"     ! DECLENCHEMENT DES LECTURES
100 TRANSFER @Dvrn TO @Int_rdgs;WAIT ! TRANSFERT DES LECTURES DANS LE
105 ! TABLEAU DES ENTIERS; PAS DE CONVERSION DE DONNEES REQUISES
107 ! PUISQUE LE FORMAT INTEGER DE L'ORDINATEUR EST IDENTIQUE A SINT
109 ! (MAIS TABLEAUX DES ENTIERS REQUIS)
110 OUTPUT @Dvm; "ISCALE'?"   ! INTERROGATION DU FACTEUR DECHELLE POUR
115                             ! LE FORMAT SINT
120 ENTER @Dvm;S              ! LECTURE DU FACTEUR D'ECHELLE
130 FOR I=1 TO Num_readings
140 Rdgs(I)=Int_rdgs(I)       ! CONVERSION DE CHAQUE LECTURE DU FORMAT
145 ! ENTIER AU FORMAT REEL(OBLIGATOIRE POUR EVITER UN
147 ! DEPASSEMENT ENTIER SUR LA LIGNE SUIVANTE)
150 R=ABS(Rdgs(I))            ! UTILISATION DE LA VALEUR ABSOLUE POUR
155                             ! VERIFIER SURCHARGE
160 IF R>=32767 THEN PRINT "OVLD" ! SI SURCHARGE, IMPRESSION D'UN
165                             ! MESSAGE
170 Rdgs(I)=Rdgs(I)*S         ! MULTIPLICATION DE LA LECTURE PAR LE
175                             ! FACTEUR D'ECHELLE
180 Rdgs(I)=DROUND(Rdgs(I),4)! VALEUR ARRONDIE A 4 CHIFFRES
190 NEXT I
200 END

```

Détermination de la vitesse de lecture

Lorsque l'événement d'échantillonnage TIMER ou la commande SWEEP est utilisé, la vitesse de lecture est simplement l'inverse de l'intervalle spécifié entre les lectures (à condition que l'erreur TRIGGER TOO FAST ne se produise pas). Par

exemple, si l'intervalle spécifié par TIMER est de $1\text{E}-4$, la vitesse de lecture sera $1/1\text{E}-4 = 10000$ lectures par seconde. Avec un autre événement d'échantillonnage, vous pouvez déterminer la vitesse de lecture en spécifiant un nombre important de lectures par déclenchement, en spécifiant également une impulsion de sortie après chaque lecture (commande EXTOUT RCOMP) et en branchant un fréquencemètre électronique sur le connecteur **Ext Out** du multimètre. La fréquence affichée sur le fréquencemètre indique la vitesse de lecture exprimée en nombre de lectures par seconde.

Une autre méthode utilise le contrôleur pour chronométrer un certain nombre de lectures initialisées par la commande TARM SGL ou TRIG SGL. Avec la mémoire-tampon d'entrée invalidée (commande INBUF OFF), l'événement SGL monopolise le bus GPIB tant que les lectures ne sont pas terminées. Cela signifie que le temps requis pour exécuter la commande TARM SGL ou TRIG SGL correspond à la durée totale de la mesure. Le programme suivant par exemple enregistre des lectures en mémoire de lecture, chronomètre TARM SGL pour 10000 lectures, divise 10000 par le temps total et affiche le nombre de lectures par seconde. La commande TIMEDATE (lignes 90 et 110) s'applique aux ordinateurs HP série 200/300 utilisant le langage HP BASIC. Pour plus de détails sur la façon d'utiliser la fonction chronomètre de votre ordinateur, se référer à son manuel d'utilisation.

```

10 REAL Num_readings          ! CREATION D'UN TABLEAU
20 Num_reading=10000          ! NOMBRE DE LECTURES=10000
30 ASSIGN @Dvm TO 722         ! AFFECTATION DE L'ADRESSE DU MULTIMETRE
40 OUTPUT @Dvm;"PRESET FAST"  ! TENSION CONTINUE, GAMME 10V, FORMAT
45 ! MEMOIRE ENTIER LONG, LECTURES RAPIDES, ARMEMENT SYN,
47 ! DECLenchement AUTO
50 OUTPUT @Dvm;"NPLC 0"       ! TEMPS D'INTEGRATION MINIMAL (500 ns)
60 OUTPUT @Dvm;"MEM FIFO"     ! VALIDE LA MEMOIRE DE LECTURE,MODE FIFO
70 OUTPUT @Dvm;"MFORMAT SINT"! FORMAT DE MEMOIRE: ENTIER SIMPLE
80 OUTPUT @Dvm;"NRDGS";Num_readings,"AUTO" ! 10000 LECTURES/
85                             ! DECLenchement, ENCHANTILLONNAGE AUTO
90 TO=TIMEDATE                ! DEPART DU CHRONOMETRE
100 OUTPUT @Dvm;"TARM SGL"    ! DECLenchement DES LECTURES
110 T1=TIMEDATE               ! ARRET DU CHRONOMETRE
120 PRINT "Lectures par secondes =";Num_readings/ (T1-T0)
125                           ! IMPRIME NOMBRE DE LECTURES PAR SECONDE
130 END

```

Si au lieu d'utiliser la mémoire de lecture, vous transférez plusieurs lectures par le bus, vous pouvez utiliser l'événement d'armement SYN (synchrone) ou l'événement de déclenchement SYN (qui monopolise également le bus tant que toutes les lectures ne sont pas terminées et transférées) et chronométrer le temps d'exécution de l'instruction ENTER ou TRANSFER du contrôleur. Cette programmation est illustrée ci-dessous (l'événement d'armement de déclenchement synchrone est sélectionné par la commande PRESET FAST, à la ligne 50).

```

10 REAL Num_readings          ! CREATION D'UN TABLEAU
20 Num_readings=300000        ! NOMBRE DE LECTURES=300000
30 ASSIGN @Dvm TO 722         ! AFFECTATION DE L'ADRESSE DU MULTIMETRE
40 ASSIGN @Buffer TO BUFFER [2*Num_readings] ! AFFECTATION DU NOM
45                             ! D'ACCES DE LA MEMOIRE-TAMPON
50 OUTPUT @Dvm;"PRESET FAST"  ! TENSION CONTINUE, GAMME 10V, FORMAT
55 ! DE SORTIE ENTIER LONG, ARMEMENT SYN, DECLenchement AUTO
60 OUTPUT @Dvm;"NPLC 0"       ! TEMPS D'INTEGRATION MINIMAL
70 OUTPUT @Dvm;"OFORMAT SINT" ! FORMAT DE SORTIE : ENTIER SIMPLE
80 OUTPUT @Dvm;"NRDGS";Num_readings,"AUTO" ! 300000 LECTURES/
85                             ! DECLenchement, ENCHANTILLONNAGE AUTO
90 TO=TIMEDATE                ! DEBUT DU CHRONOMETRAGE DES LECTURES
100 TRANSFER @Dvm TO @Buffer;WAIT ! EVENEMENT SYN, TRANSFERT DES
105                             ! LECTURES
110 T1=TIMEDATE               ! ARRET DU CHRONOMETRAGE DES LECTURES
120 PRINT "Lectures par secondes =";Num_readings/ (T1-T0)
125                             ! IMPRIME NOMBRE DE LECTURES PAR SECONDE
130 END

```

REMARQUE

Le temps requis pour extraire le facteur I_f échelle (obligatoire pour convertir les lectures au format SINT) n'est pas inclus dans le programme ci-dessus.

Le Signal EXTOUT

Vous pouvez programmer le multimètre pour qu'il génère un signal compatible TIL sur son connecteur **Ext Out** lorsqu'un événement spécifié du convertisseur A/N se produit; lorsque le multimètre génère une Demande de service GPIB ou lorsque la commande EXTOUT ONCE est exécutée. Ce signal peut être utilisé pour synchroniser un appareil externe au multimètre. Le premier paramètre de la commande EXTOUT spécifie l'événement qui génère le signal, le second paramètre spécifie la polarité du signal : NEG = vers le négatif, POS = vers le positif. Les événements qui peuvent générer un signal sur le connecteur **Ext Out** sont:

- Lecture terminée
- Groupe de lectures terminées
- Entrée terminée
- Forme d'onde d'ouverture
- Demande de service
- Exécution de la commande EXTOUT ONCE

La plupart de ces événements s'appliquent au convertisseur A/N du multimètre. La [figure 4-5](#) illustre la relation de ces événements par rapport à l'activité du convertisseur A/N.

REMARQUE

Les intervalles de temps de la [figure 4-5](#) ne servent qu'à illustrer notre propos. Ils ne correspondent pas aux intervalles réels produits par le multimètre.

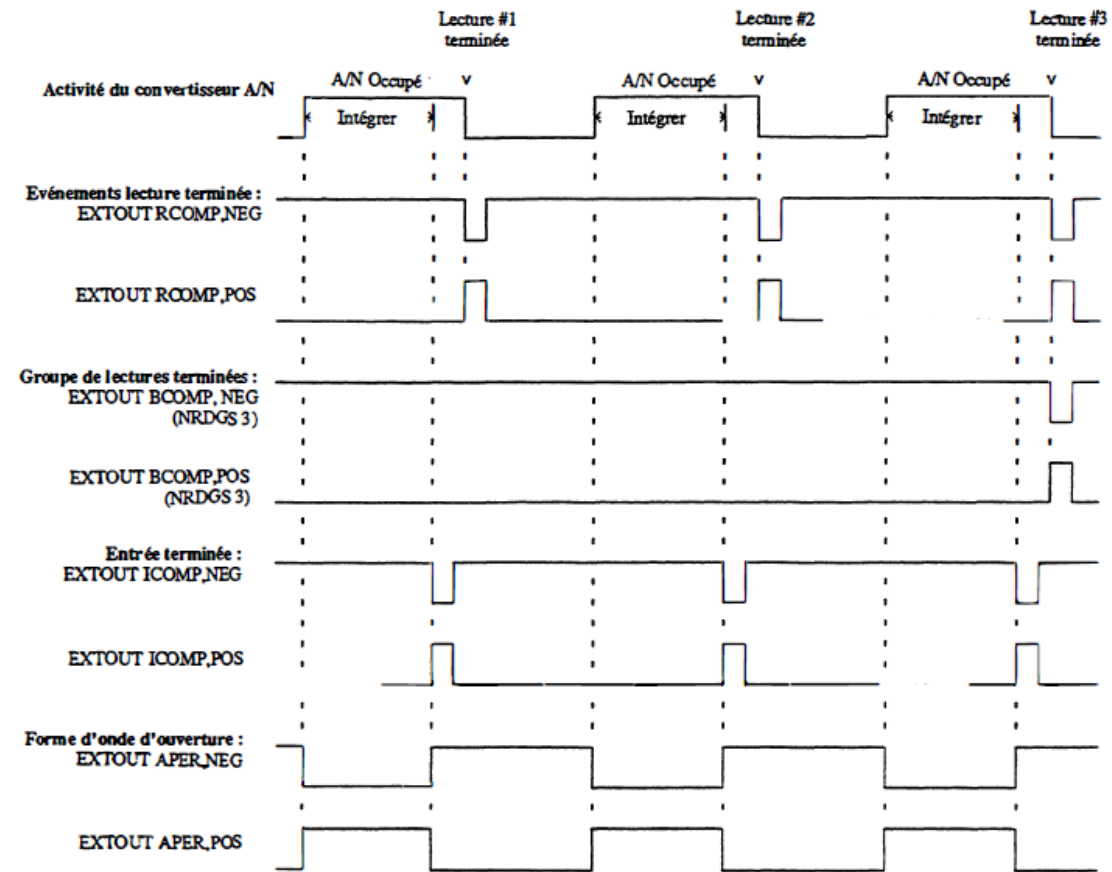


Figure 4-5 Relations entre les événements et le convertisseur A/N

Lecture terminée

Lorsqu'il est spécifié, l'événement Lecture terminée (événement RCOMP) produit une impulsion de 1 JJS après chaque lecture, quelle que soit la fonction de mesure. Pour les mesures de tensions alternatives échantillonnées (SETACV SYNC ou RNMD), une impulsion est générée après chaque lecture calculée et non pas après chaque échantillon. Cet événement peut être utilisé pour synchroniser un scanner externe sur le multimètre lorsque vous effectuez une lecture par voie de scanner.

Le programme suivant utilise l'événement RCO:MP pour synchroniser le multimètre sur un scanner (l'exemple utilise l'unité de test 3225 avec un module de scrutation (scanner) enfiché dans le logement 200). Les connexions sont illustrées à la [figure 4-6](#). Le scanner est programmé pour générer une impulsion négative après la fermeture de chaque voie (ligne 60). Cette impulsion est appliquée au connecteur **Ext Trig** du multimètre et déclenche une lecture. Après chaque lecture, le signal EXTOUT du multimètre force le scanner à passer sur la voie suivante. La fermeture de la voie génère un signal qui à son tour, déclenche la lecture suivante. Cette séquence se répète jusqu'à ce que les 6 voies aient été fermées. Les lectures sont enregistrées dans la mémoire de lecture du multimètre.

```

10 OUTPUT 722;"PRESET NORM"      ! DCV, NRDGS,1,AUTO, TARM AUTO, TRIG
15                               ! SYN 1,AUTO, ARMEMENT AUTO
20 OUTPUT 722;"MEM FIFO"         ! VALIDATION DE LA MEMOIRE DE LECTURE,
25                               ! MODE FIFO
30 OUTPUT 722;"TRIG EXT"         ! EVENEMENT DE DECLENCHEMENT= EXTERNE
40 OUTPUT 722;"EXTOUT RCOMP,NEG" ! SORTIE LECTURE TERMINEE, SIGNAL TTL
45                               ! NEGATIF, CONFIGURE LE SCANNER
50 OUTPUT 709;"SADV EXTIN"       ! PROGRESSION DU SCANNER EN FONCTION
55                               ! DU SIGNAL EXTOUT DU MULTIMETRE
60 OUTPUT 709;"CHCLOSED EXT"     ! SORTIE D'UNE IMPULSION NEGATIVE
65                               ! APRES CHAQUE FERMETURE
70 OUTPUT 709;"SCAN 201-206"    ! EXPLORE LES VOIES 1-6 SUR LE SCANNER
75 ! ENFICHE DANS LE LOGEMENT 200 ET PASSE A LA
77 ! VOIE 1, POUR COMMENCER LA SCRUTATION
80 END

```

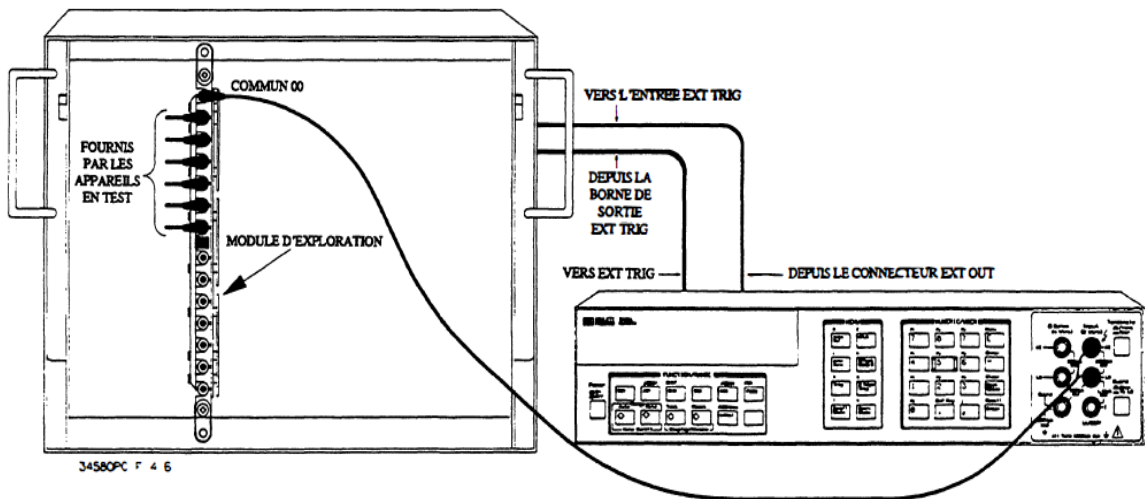


Figure 4-6 Utilisation d'un scanner externe

Groupe de lectures terminées

Lorsqu'il est spécifié, l'événement Groupe de lectures terminées (événement BCOMP) produit une impulsion de 1 μ s à la fin d'un groupe de lectures. Le nombre de lectures est spécifié par la commande NRDGS ou SWEEP. Cet événement peut être utilisé pour synchroniser un scanner externe sur le multimètre lorsque vous effectuez plusieurs lectures par voie de scanner. Le programme suivant est similaire au précédent, à part qu'il utilise l'événement BCOMP et effectue 15 lectures sur chaque voie du scanner. Les connexions sont illustrées à la [figure 4-6](#).

```

10 OUTPUT 722;"PRESET NORM"    ! DCV, NRDGS 1,AUTO, TARM AUTO, TRIG SYN
20 OUTPUT 722;"MEM FIFO"       ! VALIDATION DE LA MEMOIRE DE LECTURE,
25                               ! MODE FIFO
30 OUTPUT 722;"TRIG EXT"       ! EVENEMENT DE DECLECHEMENT = EXTERNE
40 OUTPUT 722;"EXTOUT BCOMP, NEG" ! GROUPE DE LECTURES TERMINEES,
45                               ! TTL NEGATIF
50 OUTPUT 722;"NRDGS 15, AUTO"! 15 LECTURES PAR VOIE
55                               ! CONFIGURE LE SCANNER EXTERNE
60 OUTPUT 709;"SADV EXTIN"     ! PROGRESSION DU SCANNER EN FONCTION
65                               ! DU SIGNAL EXTOUT DU MULTIMETRE

```

```

70 OUTPUT 709;"CHCLOSED EXT" ! SORTIE D'UNE IMPULSION NEGATIVE
75                               ! APRES CHAQUE FERMETURE
80 OUTPUT 709;"SCAN 201- 206" ! EXPLORE LES VOIES 1-6 SUR LE SCANNER
85                               ! ENFICHE DANS LE LOGEMENT 200 ET PASSE A
87                               ! LA VOIE 1, POUR COMMENCER LA SCRUTATION
90 END

```

Entrée terminée

L'événement Entrée complète (événement ICOMP) est similaire à RCOMP dans la mesure ou il génère une impulsion de 1 µs pour chaque lecture. Toutefois, lorsque ICOMP est spécifié, l'impulsion se produit quand le convertisseur NN a terminé d'intégrer le signal d'entrée mais avant que la lecture ne soit terminée (voir [figure 4-5](#)). L'événement ICOMP peut être utilisé avec un scanner externe lorsque vous effectuez une seule lecture par voie de scanner. Ce événement est particulièrement important lorsque vous utilisez un scanner lent (à relais). Comme l'événement ICOMP se produit avant la fin de la lecture, il fait progresser le scanner plus tôt que ne le ferait l'événement RCOMP. Le programme suivant utilise l'événement ICO.MP pour effectuer une lecture sur chacune des 6 voies du scanner. Vous remarquerez que la ligne 40 valide la mise en mémoire tampon des déclenchements. Cela empêche le multimètre de générer l'erreur TRIGGER TOO FAST (Déclenchement trop rapide) au cas où le scanner générerait une impulsion de Voie fermée avant que la lecture en cours ne soit terminée. Les connexions de cet exemple sont illustrées à la [figure 4-6](#).

```

10 OUTPUT 722;"PRESET NORM" ! DCV, NRDGS,1,AUTO, TARM AUTO, TRIG SYN
20 OUTPUT 722;"MEM FIFO" ! VALIDATION DE LA MEMOIRE DE LECTURE,
25                               ! MODE FIFO
30 OUTPUT 722;"TRIG EXT" ! EVENEMENT DE DECLENCHEMENT = EXTERNE
40 OUTPUT 722;"TBOFF ON" ! VALIDE LA MISE EN MEMOIRE-TAMPON DES
45                               ! DECLENCHEMENTS
50 OUTPUT 722;"EXTOUT ICOMP,NEG"! ENTREE TERMINEE, TTL NEGATIF
55                               ! CONFIGURE LE SCANNER EXTERNE
60 OUTPUT 709;"SADV EXTIN" ! PROGRESSION DU SCANNER EN FONCTION
65                               ! DU SIGNAL EXTOUT DU MULTIMETRE
70 OUTPUT 709;"CHCLOSED EXT" ! SORTIE D'UNE IMPULSION NEGATIVE
75                               ! APRES CHAQUE FERMETURE
80 OUTPUT 709;"SCAN 201-206" ! EXPLORE LES VOIES 1-6 SUR LE SCANNER
85                               ! ENFICHE DANS LE LOGEMENT 200 ET PASSE A

```

87

! LA VOIE 1, POUR COMMENCER LA SCRUTATION

90 END

Signal d'ouverture

Lorsqu'il est spécifié, l'événement de signal d'ouverture (APER) génère un signal qui indique lorsque le convertisseur NN mesure le signal d'entrée. Outre le fait de montrer qu'une lecture est en cours, le signal d'ouverture indique également les mesures d'auto-zéro et de gamme automatique. Ce signal peut être utilisée pour synchroniser un équipement de commutation externe au multimètre. Par exemple, pour s'assurer d'un environnement électrique "calme" pendant les mesures de haute précision, il peut être nécessaire de suspendre l'activité de l'équipement de commutation externe pendant que le convertisseur NN intègre chaque lecture. Pour ce faire, il suffit de valider l'événement APER et de programmer la commutation externe pour qu'elle ne se produise que lorsque le signal d'ouverture indique que le convertisseur A/N n'est pas en train d'intégrer le signal d'entrée. La ligne de programme suivante valide l'événement APER avec une polarité positive (voir [figure 4-5](#)):

```
OUTPUT 722;"EXTOUT APER,POS"
```

Demande de service

Lorsqu'il est spécifié, l'événement de Demande de service (SRQ) produit une impulsion de 1 μ s à chaque fois que le multimètre génère une demande de service GPIB. Cet événement peut être utilisé pour indiquer à un appareil externe (notamment à un appareil qui n'est pas raccorde au bus GPIB) que un ou plusieurs événements spécifiés se sont produits et ont générés une demande de service (pour plus de détails sur les demandes de service, voir [Utilisation du registre d'état](#) dans le [chapitre 3](#)).

REMARQUE

Lorsqu'un événement positionne le bit SRQ du registre d'état, ce bit reste à 1 tant qu'il n'est pas réinitialisé (commande CSB par exemple). Lorsqu'elle est spécifiée, l'impulsion EXTOUT SRQ est générée à chaque fois qu'un événement qui a été validé pour générer une demande de service (commande RQS) se produit. L'impulsion EXIOUT SRQ n'est pas obligatoirement générée à chaque fois que le bit SRQ est positionné; elle ne l'est que lorsqu'un événement d'état validé se produit.

Le programme suivant utilise l'événement SRQ pour synchroniser le multimètre sur un appareil externe. Le programme télécharge un sous-programme dans le multimètre. Quand le sous-programme est appelé par le contrôleur (ligne 120), il configure le multimètre pour des mesures de température à haute précision utilisant une thermistance 10 kn. Après que le sous-programme ait été appelé et exécuté, le bit O du registre d'état est positionné (Exécution du programme en mémoire terminée). Ceci correspond à la demande de service GPIB (validée à la ligne 30) et génère une impulsion sur le connecteur **Ext Out** (spécifiée par la ligne 40). Cette impulsion indique à l'appareil externe que le multimètre est configuré et prêt à effectuer des mesures.

```

10 OUTPUT 722;"SUB EXTSRQ"      ! SAUVEGARDE DU SOUS-PROGRAMME "EXTSRQ"
20 OUTPUT 722;"-PRESET NORM"    ! PRECONFIGURATION : TRIG SYN, TARM
25                               ! AUTO, NDRGS 1, AUTO
30 OUTPUT 722;"RQS 1"           ! VALIDE LE BIT EXECUTION DU SOUS
35                               ! PROGRAMME TERMINEE
40 OUTPUT 722;"EXTOUT SRQ,POS"  ! SRQ EXTERNE, IMPULSION POSITIVE
50 OUTPUT 722;"OHMF 10E3"       ! MESURE DE RESISTANCE 4-FILS, GAMME
55                               ! 10 kΩ
60 OUTPUT 722;"NPLC 100"        ! TEMPS D'INTEGRATION : 100 PLC
70 OUTPUT 722;"OCOMP ON"        ! COMPENSATION DE DECALAGE VALIDEE
80 OUTPUT 722;"TRIG EXT"        ! DECLENCHEMENT EXTERNE
90 OUTPUT 722;"MATH CTHRM10K"   ! VALIDE OPERATION MATHEMATIQUE
100 OUTPUT 722;"CSB"            ! THERMISTANCE 10 kΩ
110 OUTPUT 722;"SUBEND"         ! FIN DU SOUS-PROGRAMME
120 OUTPUT 722;"CALL EXTSRQ"    ! APPEL DU SOUS-PROGRAMME
130 END

```

EXTOUT ONCE

L'exécution de la commande EXTOUT ONCE produit une impulsion de 1 µs unique sur le connecteur **Ext Out** du multimètre. Dès que la commande XTOUT ONCE est exécutée, le signal EXTOUT est invalide. Comme l'illustre le programme suivant, la commande EXTOUT ONCE est utile dans les sous-programmes pour signaler à un appareil externe qu'un sous-programme ou un segment de sous-programme a fini de s'exécuter.

```

10 OUTPUT 722;"SUB EXTONCE"     ! SAUVEGARDE OU SOUS-PROGRAMME "EXTONCE"
20 OUTPUT 722;"EXTOUT ONCE"    ! SIGNALE A L'APPAREIL EXTERNE DE
25 ! PASSER SUR LE SIGNAL DE TENSION CONTINUE

```

```

30 OUTPUT 722;"PRESET FAST      ! LECTURES RAPIDES, TARM SYN, TRIG AUTO
40 OUTPUT 722;"MEM FIFO"       ! VALIDE LA MEMOIRE DE LECTURE, MODE FIFO
50 OUTPUT 722;"NRDGS 20"       ! 20 LECTURES PAR DECLenchement
60 OUTPUT 722;"TARM SGL"       ! DECLenche 20 LECTURES
70 OUTPUT 722;"EXTOUT ONCE"    ! SIGNALE A L'APPAREIL EXTERNE DE
75                             ! PASSER A LA MESURE CE RESISTANCE
80 OUTPUT 722;"OCOMP ON"       ! COMPENSATION CE DECALAGE VALIDEe
90 OUTPUT 722;"OHM 1E3"        ! MESURE DE RESISTANCE 2-FILS, GAMME 1kΩ
100 OUTPUT 722;"NRDGS 40"      ! 40 LECTURES PAR DECLenchemEXT
110 OUTPUT 722;"TARM SGL"      ! DECLenche 40 LECTURES
120 OUTPUT 722;"SUBEND"        ! FIN DU SOUS-PROGRAMME
130 OUTPUT 722;"CALL EXTONCE"  ! APPEL DU SOUS-PROGRAMME
140 END

```


Opérations mathématiques

Chaque opération mathématique effectue une opération spécifique sur chaque lecture et/ou sauvegarde des informations relatives à une série de mesures. Le multimètre peut exécuter les fonctions mathématiques suivantes: NULL, SCALE (Echelle), dB, dBm, FILTER (Filtre), RMS (valeur efficace) et peut également mesurer des températures. Les opérations mathématiques Statistiques et Pass/Fail (Réussite/Echec) ne modifient pas directement les lectures mais enregistrent des informations relatives aux lectures. Cette partie explique comment valider et invalider des opérations mathématiques et décrit chaque opération mathématique en détail.

Temps réel ou différé

Les opérations mathématiques peuvent être effectuées en temps réel ou différé. Lorsqu'une opération mathématique en temps réel est validée, elle est immédiatement exécutée, après chaque lecture. Le résultat peut être sauvegardé en mémoire de lecture ou transmis au contrôleur par le bus GPIB. Les opérations mathématiques différées (à l'exception de STAT et de PFAIL) s'exécutent sur chaque lecture au moment où elles sont extraites de la mémoire de lecture et copiées de la mémoire de lecture pour être affichées ou transférées dans la mémoire-tampon de sortie GPIB. (Les lectures en mémoire ne sont pas modifiées par les opérations mathématiques différées). ST AT et PF AIL utilisent les lectures en mémoire, immédiatement après exécution de la commande MMATH. Les résultats des statistiques sont sauvegardés dans des registres statistiques. Lorsqu'elle détecte une lecture hors limites, la fonction PFAIL (Réussite/Echec) positionne le bit 1 du registre d'état et affiche le message FAILED HIGH ou FAILED LOW suivant que la limite supérieure ou inférieure a été dépassée.

Validation des opérations mathématiques

Pour valider une fonction mathématique, envoyez la commande MA TH (temps réel) ou la commande MMA TH (différée), suivie de la fonction (DB, DBM, FILTER, NULL, PERC, PFAIL, RMS, SCALE, STAT) ou de l'un des paramètres relatifs aux mesures de température. (Pour plus de détails sur ces paramètres, voir [Mesure de température](#), plus loin dans ce chapitre). Une fois validée, l'opération mathématique reste active jusqu'à ce que (1) vous l'invalidez, (2) vous mettiez l'instrument hors tension, (3) vous exécutiez une commande RESET ou l'une des commandes PRESET. Par exemple, pour valider l'opération NULL, envoyez:

OUTPUT 722; "MATH NULL" !VALIDE LA FONCTION NULL EN TEMPS REEL

ou

OUTPUT 722; "MMATH NULL" !VALIDE LA FONCTION NULL EN DIFFERE

Vous pouvez valider deux fonctions mathématiques simultanément. Elles s'exécuteront sur chaque lecture dans l'ordre indiqué dans la commande. Par exemple, pour valider les fonctions NULL et SCALE, envoyez:

OUTPUT 722;"MATH NULL, SCALE" !VALIDE LES FONCTIONS NULL ET SCALE EN TEMPS REEL

ou

OUTPUT 722;"MMATH NULL, SCALE" !VALIDE LES FONCTIONS NULL ET SCALE EN DIFFERE

Pour invalider toutes les opérations mathématiques, envoyez:

OUTPUT 722;"MATH OFF" !INVALIDE TOUTES LES FONCTIONS MATHEMATIQUES EN TEMPS REEL

ou

OUTPUT 722;"MMATH OFF" !INVALIDE TOUTES LES FONCTIONS MATHEMATIQUES EN DIFFERE

Plus tard, vous pouvez revalider la ou les opération(s) invalidée(s) à l'aide de la commande MATH CONI' ou MMATH CONT. Pour revalider une seule opération mathématique (si deux opérations avaient précédemment été validées, cette commande ne revalide que la première), envoyez:

OUTPUT 722;"MATH CONT" !REVALIDE UNE SEULE FONCTION MATHEMATIQUE EN TEMPS REEL

ou

OUTPUT 722;"MMATH CONT" !REVALIDE UNE SEULE FONCTION MATHEMATIQUE EN DIFFERE

Pour revalider les deux opérations mathématiques précédemment validées, envoyez:

OUTPUT 722;"MATH CONT,CONT" !REVALIDE DEUX FONCTIONS MATHEMATIQUES EN TEMPS REEL

ou

OUTPUT 722;"MMATH CONT,CONT" !REVALIDE DEUX FONCTIONS MATHEMATIQUES EN DIFFERE

Registres mathématiques

Le **tableau 4-4** indique les registres utilisés par les fonctions mathématiques (en temps réel et/ou en différé).

Tableau 4-4 Registres mathématiques

Nom du registre	Contenu
DEGREE	Constante de temps pour les fonctions FILTER et RMS
LOWER	Plus petite lecture (fonction STAT)
MAX	Limite supérieure de la fonction PFAIL
MEAN	Moyenne des lectures (fonction STAT)
MIN	Limite inférieure de la fonction PFAIL
NSAMP	Nombre d'échantillons (fonction STAT)
OFFSET	Valeur soustraite dans les opérations NULL & SCALE
PERC	Valeur de pourcentage (fonction PERC)
REF	Valeur de référence pour la fonction DB
RES	Impédance de référence pour la fonction DBM
SCALE	Diviseur dans l'opération SCALE
SDEV	Ecart type (fonction STAT)
UPPER	Plus grande lecture (fonction STAT)
PFAILNUM	Nombre de lectures "réussies" avant détection d'une erreur (fonction PFAIL)

Vous pouvez écrire une valeur dans n'importe quel registre mathématique (à l'exception de SDEV) à l'aide de la commande SMATH. Par exemple, pour placer la valeur 22 dans le registre DEGREE, envoyez:

OUTPUT 722;"SMATH DEGREE,22"

Vous pouvez lire la valeur d'un registre mathématique à l'aide de la commande RMATH. Le programme suivant par exemple lit et imprime la valeur contenue dans le registre RES.

**10 OUTPUT 722;"RMATH RES"
20 ENTER 722;A**

```
30 PRINT A
40 END
```

NULL

La fonction NULL soustrait une valeur de chaque lecture (après la première).
L'équation est:

Résultat = Lecture - DECALAGE

où:

Lecture est toute mesure effectuée après la première.

DECALAGE est la valeur enregistrée dans le registre OFFSET/DECALAGE (typiquement la première lecture).

Quand vous sélectionnez la fonction NULL, la première lecture mesurée (temps réel) ou la première lecture extraite de la mémoire (différé) est enregistrée dans le registre de DECALAGE. Cette valeur est ensuite soustraite de toutes les lectures qui suivront. Si vous ne voulez pas que la première mesure soit la valeur nulle, vous pouvez écrire une autre valeur dans le registre de DECALAGE avec la commande SMATII. Vous devez attendre, cependant, que la première lecture soit effectuée (temps réel) ou rappelée (différé) avant de changer la valeur.

Une application de la fonction NULL sera par exemple l'amélioration de la précision des mesures de résistance 2-fils. Pour cela, sélectionnez la mesure de résistance 2-fils (commande OHM) et connectez les extrémités des fils de liaison l'une à l'autre. Ensuite, validez la fonction NULL. La première lecture effectuée (la résistance des fils de liaison) est enregistrée dans le registre de DECALAGE. Connectez les fils de liaison à la résistance inconnue à mesurer. Le 3458A soustrait la résistance des fils de liaison à chaque mesure, éliminant ainsi son effet, jusqu'à ce que la fonction NULL soit invalidée. Cette méthode n'est pas aussi précise avec les mesures de résistance 4-fils car la résistance des fils de liaison connectés ensemble ne sera probablement pas identique à celle obtenue lorsqu'ils sont connectés à la résistance inconnue. D'autre part, la résistance des fils de liaison n'est vérifiée qu'une seule fois pour une série de mesures alors qu'elle est susceptible de changer.

Le programme suivant exécute la fonction mathématique NULL en temps réel sur 20 lectures. Une fois la commande NULL exécutée, la première lecture est déclenchée par la ligne 50. La valeur dans le registre DECALAGE (OFFSET) passe

alors à 3,05. Les 20 lectures sont déclenchées par la ligne 90 et la valeur 3,05 est soustraite de chaque lecture.

```

10 OPTION BASE 1           ! BORNE INFERIEURE DU TABLEAU A 1
20 DIM Rdgs(20)            ! DIMENSIONNE LE TABLEAU POUR 20 LECTURES
30 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION : NRDGS 1, AUTO, DCV 10
40 OUTPUT 722;"MATH NULL"  ! VALIDE LA FONCTION NULL EN TEMPS REEL
50 OUTPUT 722;"TRIG SGL"   ! DECLENCHE 1 LECTURE, SAUVEGARDEE DANS
55                          ! LE REGISTRE DECALAGE
60 OUTPUT 722;"SMATH OFFSET,3.05" ! ECRIT 3.05 DANS LE REGISTRE
65                          ! DECALAGE
70 OUTPUT 722;"NRDGS 20"   ! 20 LECTURES PAR DECLENCHEMENT
80 OUTPUT 722;"TRIG SYN"   ! DECLENCHEMENT SYNCHRONE
90 ENTER 722;Rdgs(*)        ! EVENEMENT SYN, ENTRE LES LECTURES UNE
95                          ! FOIS CORRIGEEES PAR LA FONCTION NULL
100 PRINT Rdgs(*)           ! IMPRIME LES LECTURES UNE FOIS
105                          ! CORRIGEEES PAR LA FONCTION NULL
110 END

```

Le programme suivant exécute la fonction NULL en différé sur 20 lectures. Après exécution de la commande MMA TII NULL, 21 lectures sont effectuées et enregistrées en mémoire (mode d'enregistrement: FIFO). La ligne 80 rappelle la première lecture qui est enregistrée dans le registre DECALAGE. La valeur contenue dans ce registre passe alors à 3,05. Les 20 lectures restantes en mémoire sont rappelées et la fonction NULL est appliquée à chacune d'elles.

```

10 OPTION BASE 1           ! BORNE INFERIEURE OU TABLEAU A 1
20 DIM Rdgs(20)            ! DIMENSIONNE LE TABLEAU POUR 20 LECTURES
30 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION : NRDGS 1 ,AUTO, DCV 10
40 OUTPUT 722;"MEM FIFO"   ! VALIDE LA MEMOIRE DE LECTURE, MODE FIFO
50 OUTPUT 722;"MMATH NULL" ! VALIDE LA FONCTION NULL EN DIFFERE
60 OUTPUT 722;"NRDGS 21"   ! 21 LECTURES PAR DECLENCHEMENT
70 OUTPUT 722;"TRIG SGL"   ! DECLENCHE LES LECTURES
80 ENTER 722;A              ! RAPPELLE LA PREMIERE LECTURE (METHODE
85                          ! LECTURE IMPLICITE)
90 OUTPUT 722;"SMATH OFFSET,3.05" ! ECRIT 3.05 DANS LE REGISTRE
95                          ! DECALAGE
100 ENTER 722;Rdgs(*)       ! RAPPELLE LES LECTURES (METHODE
105                          ! IMPLICITE), EXECUTE L'OPERATION NULL

```

```

107                                     ! SUR CHACUNE D'ELLES
110 PRINT Rdgs(*)                     ! IMPRIME LES LECTURES UNE FOIS
115                                     ! CORRIGÉES PAR LA FONCTION NULL
120 END

```

SCALE

La fonction SCALE (Echelle) modifie les lectures en leur soustrayant un décalage et en les divisant par un facteur d'échelle. L'équation est:

Résultat = (Lecture - DECALAGE)/ECHELLE

Où:

Lecture est toute valeur mesurée.

DECALAGE est la valeur enregistrée dans le registre de DECALAGE (0 par défaut; Remarque: la première lecture n'est pas enregistrée dans le registre DECALAGE comme pour la fonction NULL).

ECHELLE est la valeur enregistrée dans le registre d'ECHELLE (1 par défaut).

Remarquez que les valeurs par défaut ne modifient pas la lecture (elles soustraient 0 et divisent par 1). Vous pouvez modifier les valeurs du registre de DECALAGE ou du registre d'ECHELLE avec la commande SMA TH.

Le programme suivant utilise la fonction d'échelle en temps réel pour diviser chacune des 20 lectures par 2. La valeur par défaut de 0 est conservée dans le registre DECALAGE pour qu'aucune soustraction ne s'opère avant la mise à l'échelle des lectures.

```

10 OPTION BASE 1                       ! BORNE INFÉRIEURE OU TABLEAU A 1
20 DIM Rdgs(20)                       ! DIMENSIONNE LE TABLEAU POUR 20 LECTURES
30 OUTPUT 722;"PRESET NORM"           ! PRECONF!GURATION: NRDGS 1, AUTO,
35                                     ! DCV 10, TRIG SYN
40 OUTPUT 722;"NRDGS 20"              ! 20 LECTURES PAR DECLenchement
50 OUTPUT 722;"MATH SCALE"            ! VALIDE LA FONCTION ECHELLE EN TEMPS
55                                     ! REEL
60 OUTPUT 722;"SMATH SCALE 2"         ! ECRIT LA VALEUR 2 DANS LE REGISTRE
65                                     ! ECHELLE
70 ENTER 722;Rdgs(*)                  ! EVENEMENT SYN, ENTRE LES LECTURES UNE
75                                     ! FOIS MISES A L'ECHELLE
80 PRINT Rdgs(*)                      ! IMPRIME LES LECTURES MISES A L'ECHELLE
90 END

```

Le programme suivant utilise la fonction Échelle différée pour soustraire la valeur 1 de chaque lecture avant de les diviser par 2.

```

10 OPTION BASE 1           ! BORNE INFERIEURE DU TABLEAU A 1
20 DIM Rdgs(20)            ! DIMENSIONNE LE TABLEAU POUR 20 LECTURES
30 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION: NRDGS 1,AUTO,
35                          ! DCV 10, TRIG SYN
40 OUTPUT 722;"MEM FIFO"    ! VALIDE LA MEMOIRE DE LECTURE, MODE FIFO
50 OUTPUT 722;"NRDGS 20"    ! 20 LECTURES PAR DECLenchement
60 OUTPUT 722;"MMATH SCALE" ! VALIDE LA FONCTION ECHELLE EN DIFFERE
70 OUTPUT 722;"SMATH OFFSET 1"! ECRIT LA VALEUR 1 DANS LE REGISTRE
75                          ! DECALAGE
80 OUTPUT 722;"SMATH SCALE 2" ! ECRIT LA VALEUR 2 DANS LE REGISTRE
85                          ! ECHELLE
90 OUTPUT 722;"TRIG SGL"    ! DECLENCHE LES LECTURES
100 ENTER 722;Rdgs(*)       ! RAPPELLE LES LECTURES (METHODE
105                          ! IMPLICITE), EXECUTE L'OPERATION
107                          ! ECHELLE SUR CHACUNE D'ELLES
110 PRINT Rdgs(*)           ! IMPRIME LES RESULTATS
120 END

```

Pourcentage

La fonction mathématique PERC détermine la différence, en pourcentage, entre une valeur mesurée et la valeur dans le registre de POUR CENT AGE.

L'équation est:

$$\text{Résultat} = ((\text{Lecture} - \text{PERC}) / \text{PERC}) \times 100$$

Où:

Lecture est toute valeur mesurée.

PERC est la valeur enregistrée dans le registre de POUR CENT AGE
(valeur à la mise sous tension: 1)

La fonction PERC vous permet de déterminer la différence (en pourcentage) entre une valeur idéale et la valeur mesurée. Le programme suivant, par exemple, détermine l'erreur de pourcentage d'une mesure de tension de 10 Vcc. La ligne 60 écrit la valeur idéale (10) dans le registre PERC (Pourcentage). La ligne 70

déclenche 20 lectures. Si la mesure est exactement 10 V cc, le 3458A affiche un 0. Si la mesure donne, par exemple, 10,1 Vcc, le résultat devient.

$$\text{Résultat} = ((10,1 - 10)/10) \times 100 = 0,01 \times 100 = 1$$

```

10 OPTION BASE 1           ! BORNE INFERIEURE DU TABLEAU A 1
20 DIM Perc(20)            ! DIMENSIONNE LE TABLEAU POUR 20
25                          ! POURCENTAGES
30 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION: NRDGS 1,AUTO,
35                          ! DCV 10, TRIG SYN
40 OUTPUT 722;"NRDGS 20"   ! 20 LECTURES PAR DECLENCHEMENT
50 OUTPUT 722;"MATH PERC"  ! VALIDE LA FONCTION POURCENTAGE EN
55                          ! TEMPS REEL
60 OUTPUT 722;"SMATH PERC 10" ! ECRIT LA VALEUR 10 DANS LE REGISTRE
65                          ! POURCENTAGE
70 ENTER 722;Perc(*)       ! EVENEMENT SYN, ENTRE LA DIFFERENCE
75                          ! POURCENTAGE
80 PRINT Perc(*)           ! IMPRIME LES DIFFERENCES EN
85                          ! POURCENTAGE
90 END

```

Le programme suivant est similaire au précédent à part qu'il utilise la fonction PERC en différé.

```

10 OPTION BASE 1           ! BORNE INFERIEURE DU TABLEAU A 1
20 DIM Perc(20)            ! DIMENSIONNE LE TABLEAU POUR 20
25                          ! POURCENTAGES
30 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION: NRDGS 1,AUTO,
35                          ! DCV 10, TRIG SYN
40 OUTPUT 722;"MEM FIFO"   ! VALIDE LA MEMOIRE DE LECTURE, MODE
45                          ! FIFO
50 OUTPUT 722;"NRDGS 20"   ! 20 LECTURES PAR DECLENCHEMENT
60 OUTPUT 722;"MMATH PERC" ! VALIDE LA FONCTION POURCENTAGE EN
65                          ! DIFFERE
70 OUTPUT 722;"SMATH PERC 10" ! ECRIT LA VALEUR 10 DANS LE REGISTRE
75                          ! POURCENTAGE
80 OUTPUT 722;"TRIG SGL"   ! DECLENCHE LES LECTURES
90 ENTER 722;Perc(*)       ! RAPPELLE LES LECTURES (METHODE

```



```

95                                ! IMPLICITE), EXECUTE L'OPERATION
97                                ! POURCENTAGE SUR CHACUNE D'ELLES
100 PRINT Perc(*)                ! IMPRIME LES DIFFERENCES EN
105                                ! POURCENTAGE
110 END

```

DB

La fonction DB calcule un rapport en décibels. L'équation est:

$$\text{Résultat} = 20\log_{10}(\text{Lecture}/\text{REF})$$

Où:

Lecture est toute valeur mesurée.

REF est la valeur du registre de référence REF (1 par défaut).

Vous pouvez changer la valeur du registre REF avec la commande SMATH.

Le programme suivant utilise la fonction DB en temps réel pour déterminer le gain de tension d'un amplificateur. La ligne 40 enregistre la tension d'entrée de l'amplificateur (0,1 V) dans le registre REF. La tension de sortie de l'amplificateur est mesurée et le gain de l'amplificateur est calculé.

```

10 OUTPUT 722;"PRESET NORM"      ! PRECONFIGURATION: NRDGS 1,AUTO,
15                                ! DCV 10, TRIG SYN
20 OUTPUT 722;"ACV"              ! MESURES DE TENSION ALTERNATIVE,
25                                ! CHANGEMENT DE GAMME AUTOMATIQUE
30 OUTPUT 722;"SETACV ANA"       ! METHODE DE MESURE ANALOGIQUE
40 OUTPUT 722;"SMATH REF 0.1"    ! ECRIT LA VALEUR 0.1 DANS LE REGISTRE
45                                ! REF
50 OUTPUT 722;"MATH DB"          ! VALIDE LA FONCTION DB EN TEMPS REEL
60 ENTER 722;A                   ! EVENEMENT SYN, ENTRE DB (Décibels)
70 PRINT A                       ! IMPRIME LES DB
80 END

```

Par exemple, si la tension d'entrée est 0,1 V et la tension de sortie est 10 V, le gain est:

$$20 \times \log_{10}(10/0,1) = 20\log_{10}100 = 40 \text{ dB}$$

Le programme suivant est similaire au précédent à part qu'il utilise la fonction DB en différé.

```

10 OUTPUT 722;"PRESET NORM"      ! PRECONFIGURATION: NRDGS 1,AUTO,
15                                ! DCV 10, TRIG SYN
20 OUTPUT 722;"ACV"              ! MESURES DE TENSION ALTERNATIVE,
25                                ! CHANGEMENT DE GAMME AUTOMATIQUE
30 OUTPUT 722;"SETACV ANA"       ! METHODE DE MESURE ANALOGIQUE
40 OUTPUT 722;"MEM FIFO"         ! VALIDE LA MEMOIRE DE LECTURE, MODE
45                                ! FIFO
50 OUTPUT 722;"SMATH REF 0.1"    ! ECRIT LA VALEUR 0.1 DANS LE REGISTRE
55                                ! REF
60 OUTPUT 722;"MMATH DB"         ! VALIDE LA FONCTION DB EN DIFFERE
70 OUTPUT 722;"TRIG SGL"        ! DECLENCHE LA LECTURE
80 ENTER 722;A                  ! RAPPELLE LES LECTURES (METHODE
85                                ! IMPLICITE), EXECUTE L'OPERATION DB
90 PRINT A                      ! IMPRIME LE RESULTAT EN DB
100 END

```

DBM

La fonction DBM calcule la puissance délivrée dans une résistance par rapport à une puissance de 1 mW. L'équation est:

$$\text{Résultat} = 10 \times \log_{10}(\text{Lecture}^2 / \text{RES} / 1 \text{ mW})$$

Où:

Lecture est toute valeur mesurée.

RES est la valeur de résistance se trouvant dans le registre RES (par défaut, 50 Ω).

Vous pouvez changer la valeur du registre RES avec la commande SMATH.

Le programme suivant utilise la fonction DBM en temps réel pour déterminer la puissance d'entrée d'un haut-parleur. La ligne 40 sauvegarde l'impédance du haut-parleur dans le registre RES (8 n dans notre exemple). La tension d'entrée au haut-parleur est ensuite mesurée et l'opération DBM est effectuée.

```

10 OUTPUT 722;"PRESET NORM"      ! PRECONFIGURATION : NRDGS 1,AUTO,
15                                ! DCV 10, TRIG SYN
20 OUTPUT 722;"ACV"              ! MESURES DE TENSION ALTERNATIVE,
25                                ! CHANGEMENT DE GAMME AUTOMATIQUE

```

```

30 OUTPUT 722;"SETACV ANA"      ! METHODE DE MESURE ANALOGIQUE
40 OUTPUT 722;"SMATH RES 8"     ! ECRIT LA VALEUR 8 DANS LE REGISTRE
45                               ! RES
50 OUTPUT 722;"MATH DBM"        ! VALIDE LA FONCTION DBM EN TEMPS REEL
60 ENTER 722;A                  ! EVENEMENT SYN, ENTRE DBM
70 PRINT A                      ! IMPRIME EN DBM
80 END

```

Si par exemple la tension d'entrée est 10 V, la puissance est:

$$10 \times \log_{10}(10^2/8/1 \text{ mW}) = 40,97 \text{ dBm}$$

Le programme suivant est similaire au précédent à part qu'il utilise la fonction DBM en différé.

```

10 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION : NRDGS 1,AUTO,
15                               ! DCV 10, TRIG SYN
20 OUTPUT 722;"ACV"          ! MESURES DE TENSION ALTERNATIVE,
25                               ! CHANGEMENT DE GAMME AUTOMATIQUE
30 OUTPUT 722;"SETACV ANA"   ! METHODE DE MESURE ANALOGIQUE
40 OUTPUT 722;"MEM FIFO"     ! VALIDE LA MEMOIRE DE LECTURE, MODE
45                               ! FIFO
50 OUTPUT 722;"SMATH RES 8"  ! ECRIT LA VALEUR 8 DANS LE REGISTRE
55                               ! RES
60 OUTPUT 722;"MMATH DBM"    ! VALIDE LA FONCTION DBM EN DIFFERE
70 OUTPUT 722;"TRIG SGL"     ! DECLENCHE LA LECTURE
80 ENTER 722;A               ! RAPPELLE LES LECTURES (METHODE
85                               ! IMPLICITE), EXECUTE L'OPERATION DBM
90 PRINT A                   ! IMPRIME LE RESULTAT EN DBM
100 END

```

Statistiques

La fonction mathématique STAT effectue en permanence cinq calculs sur la série de mesures en cours et enregistre les résultats. Ces calculs sont : 1 l'écart type, la moyenne, le nombre d'échantillons, la lecture la plus élevée (la plus grande amplitude) et la lecture la plus basse (amplitude la plus faible). Le **tableau 4-5** montre les registres STAT et leur contenu. Lisez les registres STAT avec la commande RMATH.

Tableau 4-5 Registres STAT

Registre	Résultat enregistré
SDEV	Ecart type
MEAN	Moyenne des lectures
NSAMP	Nombre de lectures dans ce groupe de mesures
UPPER	La plus importante lecture dans ce groupe de mesures
LOWER	La plus faible lecture dans ce groupe de mesures

Le programme suivant utilise la fonction ST AT en temps réel pour effectuer cinq calculs sur une série de 20 mesures de tension continue. Une fois les lectures effectuées et transmises au contrôleur, l'écart type est lu et retourné.

```
10  OPTION BASE 1          ! BORNE INFERIEURE DU TABLEAU A 1
20  DIM Rdgs(20)           ! DIMENSIONNE LE TABLEAU POUR 20 LECTURES
30  OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION: NRDGS 1,AUTO,
35                               ! DCV 10, TRIG SYN
40  OUTPUT 722"NRDGS 20"    ! 20 LECTURES PAR DECLenchement
50  OUTPUT 722;"MATH STAT"  ! VALIDE LA FONCTION STATISTIQUES EN
55                               ! TEMPS REEL
60  ENTER 722 Rdgs(*)       ! EVENEMENT SYN ENTRE LES LECTURES
70  OUTPUT 722;"RMATH SDEV" ! LIT L'ECART TYPE
80  ENTER 722;S            ! ENTRE L'ECART TYPE
90  PRINT S                ! IMPRIME L' ECART TYPE
100 END
```

Le programme suivant effectue l'opération STAT en différé sur 20 lectures enregistrées en mémoire. La fonction STAT en différé est une opération par lot, c'est-à-dire que les lectures n'ont pas à être rappelées de la mémoire dans l'ordre pour cette opération. Vous remarquerez également que les lectures doivent être enregistrées avant de valider la fonction STAT. (Dans le cas contraire, l'erreur MEMORY ERROR sera générée).

```

10 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION: NRDGS 1,AUTO,
15                               ! DCV 10, TRIG SYN
20 OUTPUT 722;"MEM FIFO"      ! VALIDE LA MEMOIRE DE LECTURE, MODE
25                               ! FIFO
30 OUTPUT 722;"NRDGS 20"      ! 20 LECTURES PAR DECLENCHEMENT
40 OUTPUT 722;"TRIG SGL"      ! DECLENCHE LES LECTURES
50 OUTPUT 722;"MMATH STAT"    ! VALIDE LA FONCTION STATISTIQUES EN
55                               ! DIFFERE
60 OUTPUT 722;"RMATH SDEV"    ! LIT L'ECART TYPE
70 ENTER 722;S                ! ENTRE L'ECART TYPE
80 PRINT S                    ! IMPRIME L'ECART TYPE
90 END

```

Pass/Fail (Réussite/Echec)

La fonction PF AIL compare chaque lecture aux limites définies dans les registres MAX et MIN. Si une limite est dépassée, le 3458A affiche "FAILED HI" ou "FAILED LO" (respectivement "dépassement limite supérieure", et "dépassement limite inférieure") et positionne le bit haut/bas dans le registre d'état. Le nombre de lectures "réussies" avant détection d'un dépassement est enregistré dans le registre PFAILNUM. La valeur par défaut du registre MAX et du registre MIN est 0. Vous pouvez changer cette valeur en utilisant la commande SMATH.

Le programme suivant utilise la fonction PFAIL en temps réel pour vérifier que 20 mesures de tension continue sont comprises entre 11 V (MAX) et 9 V (MIN). Une fois les lectures déclenchées, le bit HI/LO LIMIT du registre d'état (bit 2) est vérifié. Si un ou plusieurs dépassements sont constatés, le registre PFAILNUM est interrogé et son contenu est imprimé.

```

10  OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A 1
20  DIM Rdgs(20)                 ! DIMENSIONNE LE TABLEAU POUR 20 LECTURES
30  OUTPUT 722; "PRESET NORM"    ! PRECONFIGURATION : NRDGS 1,AUTO,
35                                ! DCV 10, TRIG SYN
40  OUTPUT 722;"MATH PFAIL"      ! VALIDE LA FONCTION PFAIL EN TEMPS REEL
50  OUTPUT 722;"SMATH MIN 9"     ! LIMITE INFERIEURE = 9 (V)
60  OUTPUT 722;"SMATH MAX 11"   ! LIMITE SUPERIEURE = 11 (V)
70  OUTPUT 722;"CSB"            ! EFFACE LE REGISTRE D'ETAT
80  OUTPUT 722;"RQS 2"          ! VALIDE LE BIT HI/LO LIMIT OU REGISTRE
85                                ! D'ETAT
90  OUTPUT 722;"NRDGS 20"       ! 20 LECTURES PAR DECLENCHEMENT
100 ENTER 722;Rdgs(*)           ! EVENEMENT SYN, ENTRE LES LECTURES
110 OUTPUT 722; "STB?"          ! INTERROGATION DES BITS POSITIONNES
115                              ! DANS LE REGISTRE D'ETAT
120 ENTER 722;A                 ! ENTRE LA REPONSE A L'INTERROGATION
130 IF BINAND(A,2) THEN         ! SI LE BIT 2 EST POSITIONNE :
140 PRINT "ECHEC DU TEST"       ! IMPRIME UN MESSAGE D'ECHEC
150 OUTPUT 722; "RMATH PFAILNUM"! INTERROGATION DU REGISTRE PFAILNUM
160 ENTER 722;B                 ! ENTRE LA REPONSE A L'INTERROGATION
170 PRINT "NOMBRE DE LECTURES "REUSSIES" AVANT DEPASSEMENT =" ;B
175                              ! IMPRIME LA REPONSE DE PFAILNUM
180 ELSE                         ! SI LE BIT 2 N'ETAIT PAS POSITIONNE:
190 PRINT                       ! IMPRIME UN MESSAGE DE REUSSITE
200 END IF
210 END

```

Le programme suivant est similaire au précédent, à part qu'il effectue l'opération PFAIL en différé sur 20 lectures enregistrées en mémoire. La fonction PFAIL en différé est une opération par lot, c'est-à-dire que les lectures n'ont pas à être rappelées de la mémoire dans l'ordre pour cette opération. Vous remarquerez également que les lectures doivent être enregistrées avant de valider la fonction PFAIL. (Dans le cas contraire, l'erreur MEMORY ERROR sera générée).

```

10  OUTPUT 722;"PRESET NORM"    ! PRECONFIGURATION : NRDGS 1,AUTO,
15                                ! DCV 10, TRIG SYN
20  OUTPUT 722;"MEM FIFO"       ! VALIDE LA MEMOIRE DE LECTURE,

```

```

30 OUTPUT 722;"SMATH MIN 9"           ! LIMITE INFERIEURE = 9 (V)
40 OUTPUT 722;"SMATH MAX 11"         ! LIMITE SUPERIEURE= 11 (V)
50 OUTPUT 722;"CSB" "                 ! EFFACE LE REGISTRE D'ETAT
60 OUTPUT 722;"RQS 2                 ! VALIDE LE BIT HI/LO LIMIT DU
65                                     ! D'ETAT
70 OUTPUT 722;"NRDGS 20"             ! 20 LECTURES PAR DECLENCHEMENT
80 OUTPUT 722;"TRIG SGL"             ! DECLENCHE LES LECTURES
90 OUTPUT 722;"MMATH PFAIL"          ! VALIDE LA FONCTION PFAIL EN
100 OUTPUT 722;"STB?";               ! INTERROGATION DES BITS
105                                   ! DANS LE REGISTRE D'ETAT
110 ENTER 722; A                     ! ENTRE LA REPONSE A
120 IF BINAND(A,2) THEN               ! SI LE BIT 2 EST POSITIONNE :
130 PRINT "ECHEC DU TEST"            ! IMPRIME UN MESSAGE D'ECHEC
140 OUTPUT 722;"RMATH PFAILNUM"      ! INTERROGATION DU REGISTRE
150 ENTER 722; B                     ! ENTRE LA REPONSE A
160 PRINT "NOMBRE DE LECTURES "REUSSIES" AVANT DEPASSEMENT =" ;B
165                                   ! IMPRIME LA REPONSE DE PFAILNUM
170 ELSE                             ! SI LE BIT 2 N'ETAIT PAS
180 PRINT "TEST REUSSI"              ! IMPRIME UN MESSAGE DE REUSSITE
190 END IF
200 END

```

FILTER

La fonction mathématique “filtre” simule la sortie d'un filtre RC passe-bas à un pôle. Elle vous permet de réduire les effets du bruit aléatoire tout en préservant les tendances à long terme:

L'équation est:

$$\text{Résultat} = (\text{Résultat précédent}) \times (\text{DEGRE}-1)/\text{DEGRE} + \text{Lecture}/\text{DEGRE}$$

Où:

Résultat précédent est fixé initialement à la valeur de la première lecture puis au résultat de la dernière opération FILTER.

Lecture est toute valeur mesurée.

DEGRE sélectionne le pas de réponse du filtre.

La valeur de DEGRE correspond au pas de réponse du filtre passe-bas. Autrement dit, si DEGRE est égal à 20, 20 lectures seront nécessaires pour que le pas de réponse atteigne 63 % de sa valeur finale. Vous pouvez obtenir une réponse plus lente ou des lectures moins brutales en augmentant la valeur de DEGRE. La constante de temps (RC) effective du filtre peut être déterminée par:

$$t = \frac{1}{f_s} \left[\frac{1}{\ln \frac{\text{DEGRE}}{\text{DEGRE}-1}} - 1 \right]$$

Où:

t = la constante de temps (R×C)

f_s = vitesse d'échantillonnage c'est-à-dire: 1/intervalle du chronomètre (si vous utilisez les commandes TIMER et NRDGS) ou 1/intervalle réel (si vous utilisez la commande S\VEEP). Si vous n'utilisez pas la commande TIMER ou SWEEP, référez-vous à “Détermination de la vitesse de lecture”, plus haut dans ce chapitre.

Si DEGRE est supérieur à 10, (R×C) est approximativement égale à:

$$t \approx (1/f_s) \times \text{DEGRE}$$

Par exemple (en utilisant la première équation), si la cadence de lecture est 200 Hz et le DEGRE 20, la constante de temps est:

$$t = \frac{1}{200} \left[\frac{1}{\ln \frac{20}{20-1}} - 1 \right] = 0.092 \text{ Secondes}$$

Avec la même cadence de lecture et la même valeur de DEGRE, la deuxième équation donne:

$$t \approx (1/200) \times 20 = 0,1 \text{ seconde}$$

RMS

L'opération mathématique RMS peut être utilisée pour calculer la valeur efficace combinée des composantes alternative et continue des signaux de basse fréquence numérisés (à l'aide de la commande DCV, DSAC ou DSDC).

REMARQUE

Pour les signaux alternatifs répétitifs de 1 Hz ou plus, la méthode de mesure alternative synchrone peut être utilisée au lieu de l'opération mathématique RMS. Si le signal alternatif est égal ou supérieur à 10 Hz, vous pouvez utiliser la méthode de mesure alternative analogique. Si le signal est égal ou supérieur à 20 Hz, vous pouvez utiliser la méthode de mesure alternative aléatoire. Vous pouvez également déterminer la valeur efficace de la composante alternative des ondes sinusoïdales en les numérisant (commande DCV, DSAC ou DSDC) et en validant la fonction mathématique STATS. Après plusieurs lectures, le résultat dans le registre SDEV correspondra à la valeur efficace de la composante alternative du signal d'entrée.

L'équation correspondant à la fonction RMS est:

Résultat = racine carrée de l'opération FILTRE précédente avec l'entrée (lecture) de FILTRE d'abord élevée au carré.

Mesure de température

Les fonctions mathématiques CTHRM et FTHRM convertissent la résistance mesurée d'une thermistance ou RTD en degrés Celsius ou Fahrenheit. Le [tableau 4-6](#) décrit chacune de ces fonctions. La résistance peut être mesurée en mode 2-fils (commande OHM) ou 4-fils (commande OHMF). Pour une précision optimale, utilisez le mode 4-fils. Les conditions qui affectent la précision d'une mesure de résistance affecteront également la précision de la mesure de température. (Voir [Résistance](#) et [Etalonnage](#) au [chapitre 3](#)).

Tableau 4-6 Fonctions de mesure de température

Opération mathématique	Description
CTHRM2K	Résultat = température (°C) d'une thermistance de 2 kΩ (40653A)
CTHRM	Résultat = température (°C) d'une thermistance de 5 kΩ (40653B)
CTHRM10K	Résultat= température (°C) d'une thermistance de 10 kΩ (40653C)
FTHRM2K	Résultat= température (°F) d'une thermistance de 2 kΩ (40653A)
FTHRM	Résultat= température (°F) d'une thermistance de 5 kΩ (40653B)
FTHRM10K	Résultat = température (°F) d'une thermistance de 10 kΩ (40653C)
CRTD85	Résultat= température (°C) d'un RTD de 100 kΩ avec 1 alpha de 0,00385 (40654A ou 406548)
CRTD92	Résultat= température (°C) d'un RTD de 100 kΩ avec alpha de 0,003916
FRTD85	Résultat= température (°F) d'un RTD de 100 kΩ avec alpha de 0,00385 (40654A ou 40654B)
FRTD92	Résultat= température (°F) d'un RTD de 100 kΩ avec alpha de 0,003916

L'exemple suivant effectue une mesure de température en utilisant une thermistance de 10 kΩ et retourne le résultat en degrés Celsius (°C).

```
10 OUTPUT 722;"PRESET NORM"      ! PRECONFIGURE LE MULTIMETRE; SUSPEND
15                                ! LES LECTURES
20 OUTPUT 722;"OHMF 10E3"         ! SELECTIONNE MODE 4-FILS, GAMME 10 kΩ
30 OUTPUT 722;"MATH CTHRM10K"     ! CONVERSION EN °C, THERMISTANCE 10 kΩ
40 OUTPUT 722;"TRIG SGL"          ! DECLENCHE LA LECTURE
```

```
50 ENTER 722;A  
60 PRINT A  
70 END
```

```
! ENTRE LE RESULTAT  
! IMPRIME LE RESULTAT
```

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5 Numérisation

Introduction	210
Méthodes de numérisation	211
Vitesse d'échantillonnage	213
Déclenchement par niveau	215
Numérisation de tensions continues	220
Echantillonnage direct	225
Sous-échantillonnage	229
Visualisation des données échantillonnées	239

Introduction

La numérisation consiste à convertir un signal analogique continu en une série d'échantillons discrets (lectures). La **figure 5-1** illustre le résultat de la numérisation d'une onde sinusoïdale. Ce chapitre traite des différentes méthodes de numérisation des signaux, de l'importance de la vitesse d'échantillonnage et explique comment définir des déclenchements par niveau.

REMARQUE

Pour compléter l'information contenue dans ce chapitre, l'annexe D du manuel en anglais traite des erreurs de déclenchement et de base de temps qui affectent les mesures numérisées.

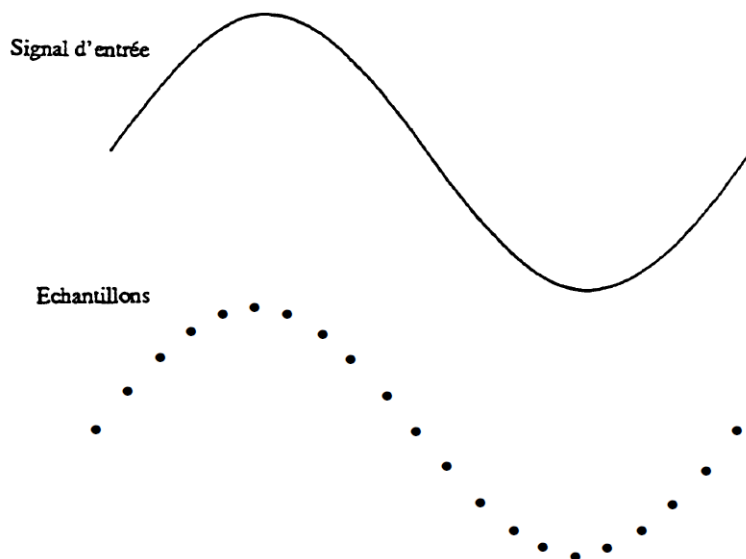


Figure 5-1 Numérisation d'une onde sinusoïdale

Méthodes de numérisation

Le multimètre peut numériser des signaux en effectuant des mesures de tension continue, par échantillonnage direct ou sous-échantillonnage. Le [tableau 5-1](#) montre les caractéristiques respectives de ces trois méthodes de numérisation. La [figure 5-2](#) et [figure 5-3](#) est un schéma de principe simplifié qui indique le cheminement du signal du multimètre pour chaque méthode de numérisation et illustre les connexions des bornes frontales valables pour toutes les méthodes de numérisation.

Tableau 5-1 Méthodes de numérisation

Méthode de numérisation	Vitesse d'échantillonnage maximale	Largeur de bande	Signal répétitif requis
Mesure de tension continue	100 k/sec	CC - 150 kHz ^[a]	Non
Échantillonnage direct	50 k/sec	CC - 12 MHz	Non
Sous échantillonnage	100 M/sec ^[b]	CC - 12 MHz	Qui

[a] Dépend de la gamme. Pour plus de détails, voir ["Annexe A : Spécifications"](#) à la page 411
[b] Vitesse d'échantillonnage réelle (pour plus de détails, voir [Sous-échantillonnage](#), plus loin dans ce chapitre

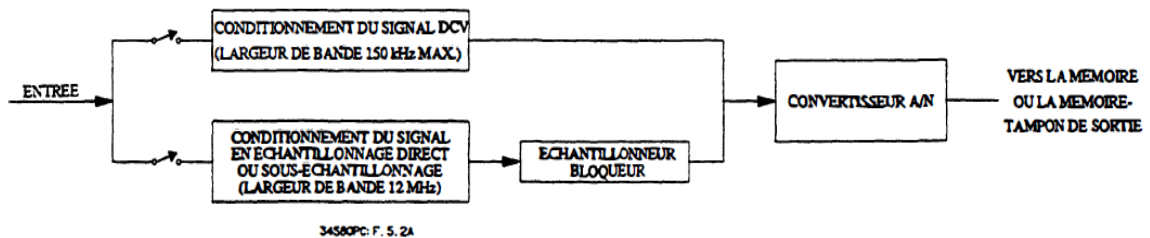


Figure 5-2 Méthodes de numérisation

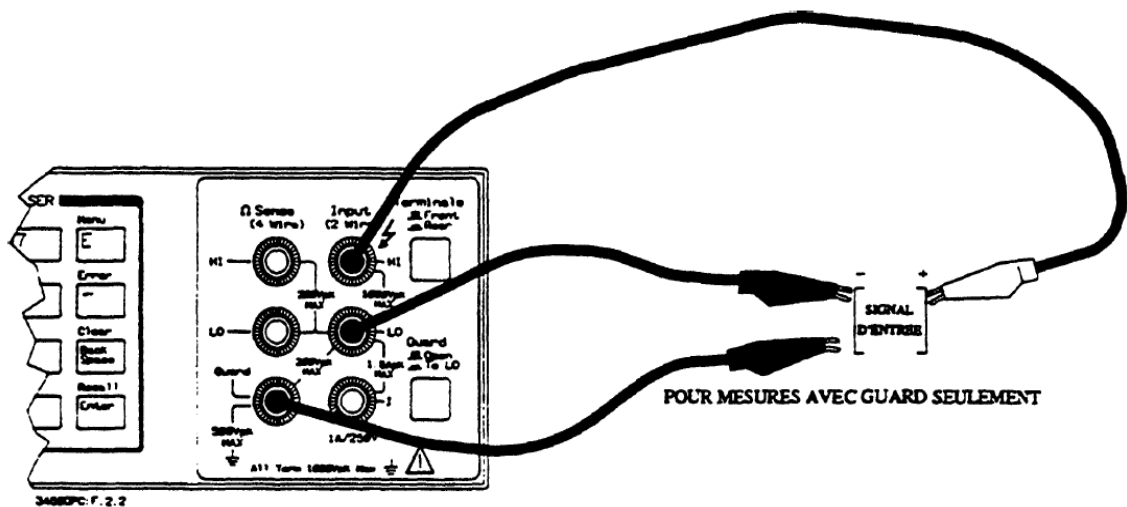


Figure 5-3 Numérisation du signal et connexions de mesure

Dans la plupart des opérations de numérisation, le multimètre adopte le mode grande vitesse à chaque fois qu'un échantillon est initialisé. En mode grande vitesse, le multimètre se consacre exclusivement à prendre des échantillons. Cela signifie qu'il ne traitera aucune commande tant que le nombre d'échantillons spécifié n'est pas atteint.

En mode grande vitesse, lorsque les échantillons sont directement transmis en mémoire-tampon de sortie, le multimètre attend que chaque échantillon soit extrait de la mémoire-tampon de sortie avant d'y placer l'échantillon suivant. Ainsi, aucun échantillon ne risque d'être perdu du fait des limites de vitesse imposées par le bus/contrôleur. (Lorsqu'il n'est pas en mode grande vitesse, le multimètre "écrase" les échantillons encore en mémoire-tampon de sortie dès qu'un nouvel échantillon est disponible). Pour plus de détails à ce sujet, voir [Mode grande vitesse](#) au [chapitre 4](#).

Vitesse d'échantillonnage

Le théorème de Nyquist ou théorème d'échantillonnage stipule que:

Si un signal continu, à largeur de bande limitée ne renferme aucune composante de fréquence supérieure à F , alors le signal original peut être récupéré sans distortion repliement s'il est échantillonné à une vitesse supérieure à $2F$ échantillons par seconde.

Ce qui signifie que la vitesse d'échantillonnage du multimètre doit au moins être égale à deux fois la composante de fréquence la plus élevée du signal mesure. La vitesse d'échantillonnage est l'inverse de l'intervalle de temps spécifié par la commande TIMER ou de *l'intervalle_réel* spécifié par la commande SWEEP. Si par exemple *l'intervalle_réel* spécifié est de $20\text{ }\mu\text{s}$, la vitesse d'échantillonnage sera de: $1/20\text{ }\mu\text{s} = 50\text{ 000}$ échantillons par seconde.

La [figure 5-4](#) montre une onde sinusoïdale échantillonnée à une vitesse légèrement inférieure à $2F$. Le résultat est une *fréquence apparente* (ligne en pointillé) (phénomène de repliement) très différente de celle du signal d'entrée.

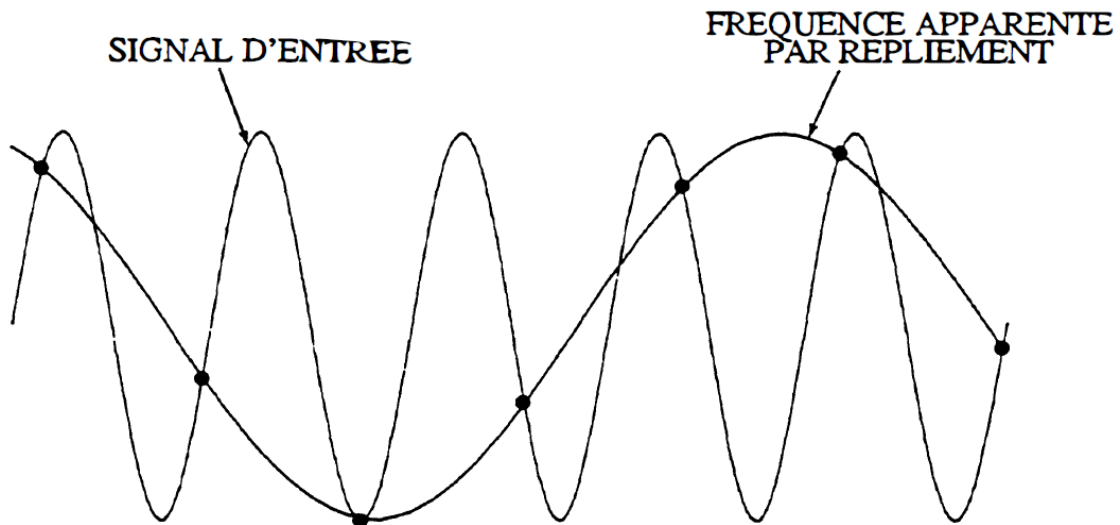


Figure 5-4 Distortion causée par un sous-échantillonnage

Certains numériseurs sont équipés d'un filtre passe-bas anti-repliement interne qui coupe brusquement la fréquence lorsqu'elle équivaut à la moitié de la vitesse d'échantillonnage du numériseur. Ceci limite la largeur de bande du signal d'entrée et élimine tout risque de repliement. Le multimètre ne dispose pas d'un tel filtre, d'une part parce qu'il a une vitesse d'échantillonnage variable pour la numérisation des tensions continues, et d'autre part pour préserver la largeur de bande supérieure pour les mesures à haute fréquence. Si cela vous gêne, vous pouvez toujours ajouter un filtre anti-repliement externe au multimètre.

Déclenchement par niveau

Pour numériser, il est important de commencer l'échantillonnage à un point défini du signal d'entrée – quand celui-ci passe par 0 volt par exemple ou lorsqu'il arrive à mi-distance de son amplitude crête négative ou positive. Le déclenchement par niveau vous permet de spécifier le début d'un échantillonnage (par rapport à une tension et une pente). La [figure 5-5](#) par exemple montre un échantillonnage qui démarre lorsque le signal d'entrée passe par 0 volt avec une pente positive.

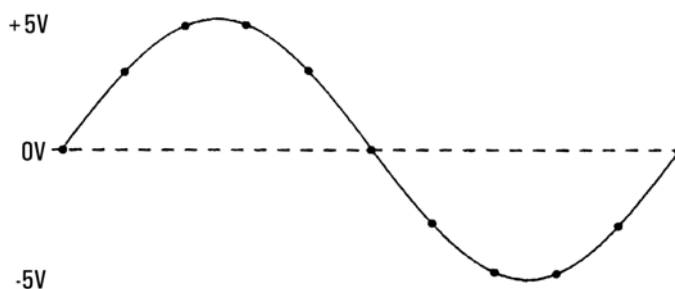


Figure 5-5 Déclenchement au passage du signal par 0 volt, avec une pente positive

Exemples de déclenchement par niveau

Pour les mesures de tension continue, le déclenchement par niveau peut être utilisé comme événement de déclenchement (commande TRIG LEVEL) ou comme événement d'échantillonnage (commande NRDGS *n*, LEVEL). En mode échantillonnage direct, le déclenchement par niveau ne peut être utilisé que comme événement de déclenchement. En mode sous-échantillonnage, le déclenchement par niveau ne peut être utilisé que comme événement Source de synchronisation (cet événement est décrit en détails plus loin dans ce chapitre. Voir [Sous-échantillonnage](#)). Les exemples de programme ci-après utilise la méthode de numérisation des tensions continues (DCV) et la gamme 10 V. Pour plus de détails sur la façon d'utiliser les déclenchements par niveau suivant la méthode de numérisation, voir [Numérisation de tensions continues](#), [Echantillonnage direct](#) et [Sous-échantillonnage](#), plus loin dans ce chapitre.

La commande LEVEL spécifie la tension de déclenchement sous forme de pourcentage de la gamme de la mesure. (Les gammes sont données plus loin dans ce chapitre avec chaque méthode de numérisation). La commande LEVEL spécifie également le couplage (CC ou CA) avec les circuits de détection de niveau. (Le couplage du déclenchement par niveau n'affecte pas le couplage du signal mesuré et réciproquement; il est ainsi possible de coupler le signal d'entrée en courant continu avec les circuits de détection de niveau et de le coupler en courant alternatif avec le convertisseur A/N). La commande SLOPE spécifie la pente à utiliser. Les valeurs de mise sous tension par défaut spécifient une tension de 0% de la gamme courante (déclenchement au passage du signal par 0 volt), une pente positive et un couplage alternatif avec les circuits de détection de niveau. A l'état de mise sous tension, vous pouvez donc sélectionner le déclenchement illustré à la [figure 5-6](#) en spécifiant simplement l'événement de déclenchement LEVEL (commande TRIG LEVEL).

Le programme suivant spécifie un déclenchement au passage du signal d'entrée par +5 V (50% de la gamme IOV) sur une pente négative (couplage ca). En supposant que le signal d'entrée ait une valeur crête de 10 V et que la lecture s'opère sur la gamme 10 V, le résultat sera celui illustré à la [figure 5-6](#).

```

10 OUTPUT 722;"PRESET DIG"      ! NUMERISATION DE TENSION CONTINUE,
15                               ! GAMME 10 V
20 OUTPUT 722;"TRIG LEVEL"      ! SELECTIONNE L'EVENTEMENT DE
25                               ! DECLENCHEMENT PAR NIVEAUX
30 OUTPUT 722;"SLOPE NEG"       ! DECLENCHEMENT SUR PENTE NEGATIVE DU
35                               ! SIGNAL
40 OUTPUT 722;"LEVEL 50,AC"     ! DECLENCHEMENT A 50% DE LA GAMME 10 V,
45                               ! COUPLAGE CA
50 END

```

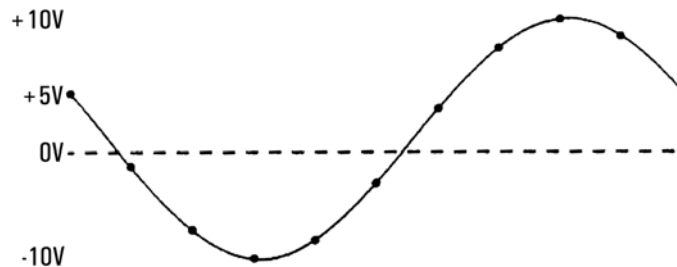


Figure 5-6 Déclenchement à 50%, pente négative, couplage CA

Le programme suivant spécifie un déclenchement au passage du signal d'entrée par -5 V (-50% de la gamme 10V) sur une pente positive (couplage ca). En supposant que le signal d'entrée ait une valeur crête de ± 10 V et que la lecture s'opère sur la gamme 10 V, le résultat sera celui illustré à la [figure 5-7](#).

```

10 OUTPUT 722;"PRESET DIG"    ! NUMERISATION DE TENSION CONTINUE,
15                             ! GAMME 10 V
20 OUTPUT 722;"TRIG LEVEL"    ! SELECTIONNE L'EVENEMENT DE
25                             ! DECLenchement PAR NIVEAUX
30 OUTPUT 722;"SLOPE POS"     ! DECLenchement SUR PENTE POSITIVE DU
35                             ! SIGNAL
40 OUTPUT 722;"LEVEL -50,AC"   ! DECLenchement A -50% DE LA GAMME 10 V,
45                             ! (-5 V) COUPLAGE CA
50 END

```

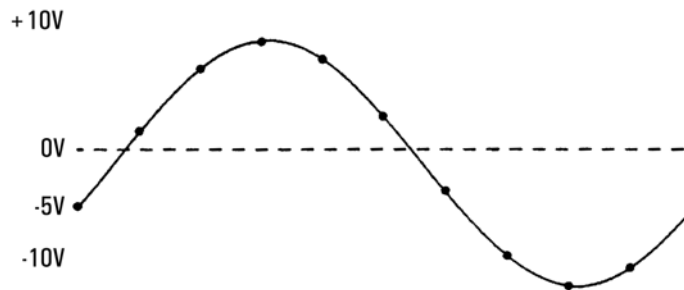


Figure 5-7 Déclenchement à -50%, pente positive, couplage CA

Dans le programme suivant, le signal d'entrée est couplé en courant continu avec les circuits de détection de niveau. C'est un signal alternatif de 5 Volts crête centré sur - 5 V cc. Dans ce cas, un pourcentage négatif de la gamme (-25%) est utilisé pour déclencher la mesure à -2,5V, sur une pente positive. La [figure 5-8](#) illustre le résultat.

```

10 OUTPUT 722;"PRESET DIG"    ! NUMERISATION DE TENSION CONTINUE,
15                             ! GAMME 10 V
20 OUTPUT 722;"TRIG LEVEL"    ! SELECTIONNE L'EVENEMENT DE
25                             ! DECLENCHEMENT PAR NIVEAUX
30 OUTPUT 722;"SLOPE POS"     ! DECLENCHEMENT SUR PENTE POSITIVE DU
35                             ! SIGNAL
40 OUTPUT 722;"LEVEL -25,DC"  ! DECLENCHEMENT A -25% DE LA GAMME 10 V,
45                             ! COUPLAGE CC
50 END

```

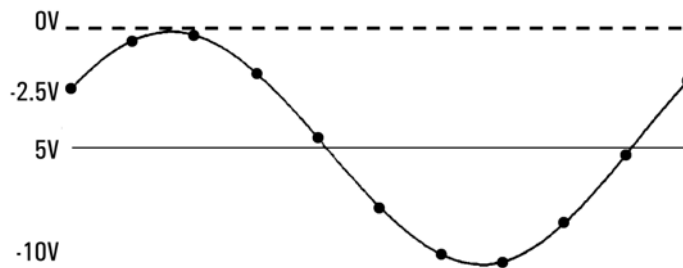


Figure 5-8 Déclenchement à -2S%, pente positive, couplage CC

Filtre de niveau

Lorsqu'elle est validée, la fonction de filtre de niveau connecte un circuit du filtre passe-bas mono-pôle à l'entrée des circuits de détection de niveau. Le filtre passe-bas a une fréquence de coupure à 3 dB de 75 kHz et empêche les composantes de haute fréquence du signal d'entrée de provoquer de faux déclenchements. Pour valider le filtre de niveau, envoyez :

`OUTPUT 722; "LFILTER ON"`

REMARQUE

La fonction Filtre de niveau permet également de réduire la sensibilité du multimètre aux bruits de haute fréquence pour les mesures de fréquence et de période ou les mesures de tension alternative ou alternative + continue effectuées à l'aide de la méthode synchrone (commande SETACV SYNC).

Numérisation de tensions continues

La numérisation peut être effectuée en spécifiant des mesures de tension continues avec un temps d'intégration court et un court intervalle entre les échantillons ("court" par rapport à la fréquence du signal à numériser). Cette pratique est considérée comme une numérisation bien que le circuit échantillonneur-bloqueur (Track & Hold) du multimètre ne soit pas utilisé. L'avantage de cette méthode de numérisation sur celle de l'échantillonnage direct (décrite plus loin) réside dans un temps d'intégration programmable et une vitesse d'échantillonnage maximale de 100 000 échantillons par seconde (contre 50 000 pour l'échantillonnage direct). Les inconvénients de cette méthode sont une plus grande instabilité des déclenchements (voir ["Annexe A : Spécifications"](#) à la page 411), l'impossibilité de coupler le signal d'entrée en courant alternatif et une largeur de bande de 150 kHz maximum (contre 12 MHz pour la méthode d'échantillonnage direct ou de sous-échantillonnage). Comme l'échantillonneur-bloqueur n'est pas utilisé dans ce type de numérisation, chaque échantillon est beaucoup plus large (500 nanosecondes minimum contre 2 nanosecondes pour l'échantillonnage direct ou le sous-échantillonnage).

La commande PRESET DIG configure le multimètre pour les mesures de tension continue avec une vitesse d'échantillonnage de 50 000 échantillons par seconde. PRESET DIG sélectionne 3 μ s de temps d'intégration par défaut et un déclenchement au passage du signal d'entrée par 0 volt sur sa pente positive. Les commandes primaires exécutées par PRESET DIG sont les suivantes:

```
TARM HOLD -- Suspension du déclenchement
TRIG LEVEL -- Événement de déclenchement LEVEL (niveau)
LEVEL 0,AC -- Déclenchement à 0% de la gamme (0 V), couplage CA
TIMER 20E-6 -- Intervalle de 20  $\mu$ s entre les échantillons
NRDGS 256,TIMER -- 256 échantillons par déclenchement, événement
d'échantillonnage TIMER
DCV 10 -- Mesures de tension continue, gamme 10 V
DELAY 0 -- Pas de retard
APER 3E-6 -- 3  $\mu$ s de temps d'intégration
MFORMAT SINT -- Format de mémoire Entier simple (SINT)
OFORMAT SINT -- Format de sortie Entier simple (SINT)
AZERO OFF -- Invalidation de la fonction d'auto-zéro
```


DISP OFF -- Invalidation de l'affichage

Après avoir exécuté la commande PRESET DIG, vous pouvez augmenter la vitesse d'échantillonnage en diminuant l'intervalle TIMER et en réduisant le temps d'intégration à l'aide de la commande APER. Le temps d'intégration minimal pour les mesures de tension continue est de 500 nanosecondes.

Remarques relatives aux mesures de tension continue

- Pour numériser des tensions continues, il est conseillé d'utiliser le format de mémoire/sortie SINT lorsque le temps d'intégration est $1,4 \mu\text{s}$ et le format de mémoire/sortie DINT lorsqu'il est $\geq 1,4 \mu\text{s}$. (Ces formats sont décrits en détails dans le [chapitre 4](#).)

REMARQUE

Pour transférer des échantillons dans la mémoire de lecture et ou au contrôleur le plus rapidement possible, vous pouvez utiliser le format de mémoire/sortie SINT avec des temps d'intégration allant jusqu'à $10,8 \mu\text{s}$. Toutefois, lorsque le temps d'intégration est $> 1,4 \mu\text{s}$, le convertisseur A/N fournit davantage de bits de résolution que ne peut en accepter le format SINT (le(s) bit(s) le(s) moins significatif(s) sont ignorés). Si vous utilisez le format de mémoire/sortie SINT avec des temps d'intégration $> 10,8 \mu\text{s}$, le multimètre doit convertir les données en provenance du convertisseur A/N et ne peut conserver le mode grande vitesse. Il est conseillé d'utiliser le format de mémoire/sortie DINT (compatible avec le mode grande vitesse) lorsque le temps d'intégration est $> 10,8 \mu\text{s}$.

- Lorsque vous effectuez des mesures à l'aide de l'événement d'échantillonnage TIMER ou de la commande SWEEP, la fonction de changement automatique de gamme est invalidée. Vous pouvez utiliser la gamme sélectionnée par PRESET DIG (gamme 10 V) ou spécifier une autre gamme comme premier paramètre de la commande DCV ou RANGE (paramètre *entrée_max*). Les paramètres *entrée_max* et les gammes auxquelles ils correspondent sont les suivants:

Paramètres Entrée_max	Sélectionne la gamme	Pleine échelle
0 à 0,12	100 mV	120 mV
$>0,12$ à 1,2	1 V	1,2 V
$>1,2$ à 12	10 V	12 V

Paramètres Entrée_max	Sélectionne la gamme	Pleine échelle
>12 à 120	100 V	120 V
>120 à 1E3	1000 V	1050 V

- La hiérarchie de déclenchement du multimètre (événement d'armement, de déclenchement et d'échantillonnage) s'applique aux numérisations de tensions continues. Pour plus de détails sur cette hiérarchie, se reporter au [chapitre 4](#) Pour numériser des tensions continues, vous pouvez utiliser soit l'événement d'échantillonnage TIMER et la commande NRDGS *n*,TIMER soit la commande SWEEP. Les commandes NRDGS et SWEEP sont interchangeables et le multimètre utilise celle des deux qui a été spécifiée en dernier. (Avec la commande SWEEP, l'événement d'échantillonnage est automatiquement défini à TIMER).
- Le temps d'ouverture correspond au temps pendant lequel le multimètre échantillonne le signal d'entrée. Pour l'échantillonnage direct et le sous-échantillonnage (qui utilisent le circuit échantillonneur-bloqueur), le temps d'ouverture est fixé à 2 nanosecondes et ne peut pas être modifié. Pour la numérisation des tensions continues, le temps d'ouverture est égal au temps d'intégration du convertisseur A/N et peut varier entre 500 ns et 1 s. Le multimètre établit une moyenne sur le signal d'entrée pendant son temps d'ouverture. Une erreur d'amplitude est introduite lorsque le signal change pendant le temps d'ouverture. Le [tableau 5-2](#) indique les fréquences du signal d'entrée pour lesquelles une erreur d'amplitude de 3 dB se produit pour les temps d'ouverture sélectionnés ainsi que la résolution (en bits) fournie par chacun de ces temps d'ouverture.

Tableau 5-2 Erreur d'amplitude et résolution par rapport à l'ouverture

Temps d'ouverture	Bits de résolution	Fréquence pour une erreur de 3 dB
2 ns	16	100 MHz
500 ns	15	400 kHz
1 µs	16	206 kHz
3 µs	17	69 kHz
6 µs	18	35 kHz
100 µs	21	2 kHz

Exemple DCV

Le programme suivant prend 256 échantillons de tension continue à la vitesse de 100 000 échantillons par seconde et les place en mémoire de lecture en utilisant le format SINT. Les échantillons sont ensuite transmis au contrôleur au format de sortie SINT. Le contrôleur convertit les échantillons reçus au format SINT et les sauvegarde. Si vous supprimez la ligne 100 du programme, les échantillons seront directement transmis au contrôleur sans passer par la mémoire de lecture. Le contrôleur et le bus doivent toutefois pouvoir transférer des échantillons à la vitesse d'au moins 200 Ko/seconde sinon, le multimètre générera l'erreur TRIGGER TOO FAST (Déclenchement trop rapide). Pour plus de détails à ce sujet, voir [Transfert à grande vitesse par le bus GPIB](#) au [chapitre 4](#).

```

10 OPTION BASE 1                !BORNE INFERIEURE DU TABLEAU A 1
20 Num_samples=256              !SPECIFIE LE NOMBRE D'ECHANTILLONS
30 INTEGER Int_samp(1:256) BUFFER !CREATION DU TABLEAU DES
35                               !ENTIERS EN MEMOIRE-TAMPON
40 ALLOCATE REAL Samp(1:Num_samples) !CREE LE TABLEAU DES REELS
45                               !POUR LES ECHANTILLONS
50 ASSIGN @Dvm TO 722           !AFFECTATION DE L'ADRESSE DU MULTIMETRE
60 ASSIGN @Int_samp TO BUFFER Int_samp(*) !AFFECTATION DU NOM
65                               !D'ACCES DE LA MEMOIRE-TAMPON
70 OUTPUT @Dvm;"PRESET DIG"     !TARM HOLD, DCV, GAMME 10V, 256
71 !ECHANTILLONS PAR DECLENCHEMENT
72 !EVENEMENT D'ECHANTILLONNAGE TIMER, INTERVALLE = 20 µs, NIVEAU
75 !DE DECLENCHEMENT (0%,COUPLAGE CA), 3 µs DE TEMPS
77 !D'INTEGRATION, FORMATS SINT
80 OUTPUT @Dvm;"TIMER 10E-6"    !INTERVALLE DE 10 µs ENTRE LES
82                               !ECHANTILLONS
90 OUTPUT @Dvm;"APER 1.4E-6"    !OUVERTURE MAXIMALE POUR VITESSE
95                               !D'ECHANTILLONNAGE DE 100 kHz
100 OUTPUT @Dvm;"MEM FIFO"      VALIDE LA MEMOIRE DE LECTURE, MODE FIFO
110 OUTPUT @Dvm;"TARM SYN"      !ARMEMENT DE DECLENCHEMENT SYNCHRONE
120 TRANSFER @Dvm TO @In t_samp;WAIT !EVENEMENT SYNCHRONE,
121 !TRANSFERT DES LECTURES EN MEMOIRE DE LECTURE PUIS DANS LE
125 !TABLEAU DES ENTIERS DE L'ORDINATEUR; PAS DE CONVERSION DE
127 !DONNEES REQUISES PUISQUE LE FORMAT INTEGER DE L'ORDINATEUR
129 !EST IDENTIQUE A SINT (MAIS TABLEAUX DES ENTIERS REQUIS)

```

```

130 OUTPUT @Dvm; "ISCALE?"      !INTERROGATION DU FACTEUR D'ECHELLE POUR
135                             !LE FORMAT SINT
140 ENTER @Dvm;S                !ENTRE LE FACTEUR D'ECHELLE
150 FOR I=1 TO Num_samples
160 Samp(I)=Int_samp(I)         !CONVERSION DE CHAQUE LECTURE DU FORMAT
165 !ENTIER AU FORMAT REEL(OBLIGATOIRE POUR EVITER UN
167 !DEPASSEMENT ENTIER SUR LA LIGNE SUIVANTE)
170 R=ABS(Samp(I))              !UTILISATION DE LA VALEUR ABSOLUE POUR
175                             !VERIFIER LA SURCHARGE
180 IF R>=32767 THEN PRINT "OVLD" !SI SURCHARGE, IMPRESSION D'UN
185                             !MESSAGE
190 Samp(I)=Samp(I)*S           !MULTIPLICATION DE LA LECTURE PAR LE
195                             !FACTEUR D'ECHELLE
200 Samp(I)=DROUND(Samp(I),4) !VALEUR ARRONDIE A 4 CHIFFRES
210 NEXT I
220 END

```

Echantillonnage direct

L'échantillonnage direct est similaire à la numérisation des tensions continues au sens où les échantillons sont pris en temps réel et séparés les uns des autres par un intervalle de temps spécifié. La différence entre ces deux méthodes réside dans le fait que l'échantillonnage direct utilise l'échantillonneur bloqueur, une largeur de bande supérieure (12 MHz) et offre une instabilité de déclenchement moindre comparée à la numérisation des tensions continues (voir **“Annexe A : Spécifications”** à la page 411). L'échantillonneur-bloqueur prend un échantillon très rapide du signal d'entrée puis retient la valeur pendant que le convertisseur NN l'intègre. A cause de ce circuit, la largeur de chaque échantillon est réduite de 500 nanosecondes minimum (numérisation des tensions continues) à 2 nanosecondes (échantillonnage direct). Cette dernière méthode s'avère donc idéale pour capturer l'amplitude crête d'une impulsion étroite. L'inconvénient de l'échantillonnage direct réside dans une vitesse moindre (50 000 échantillons par seconde contre 100 000 pour les tensions continues).

Vous spécifiez l'échantillonnage direct à l'aide de la commande DSAC ou DSDC. La commande DSAC sélectionne le couplage ca qui permet de ne mesurer que la composante alternative du signal d'entrée. La commande DSDC sélectionne le couplage cc qui permet de mesurer à la fois les composantes alternative et continue du signal d'entrée.

La **figure 5-9** illustre 20 échantillons pris sur un signal sinusoïdal (les numéros indiquent l'ordre dans lequel ces échantillons ont été pris). En mode Echantillonnage direct, l'intervalle minimal entre les échantillons est de 20 μ s.

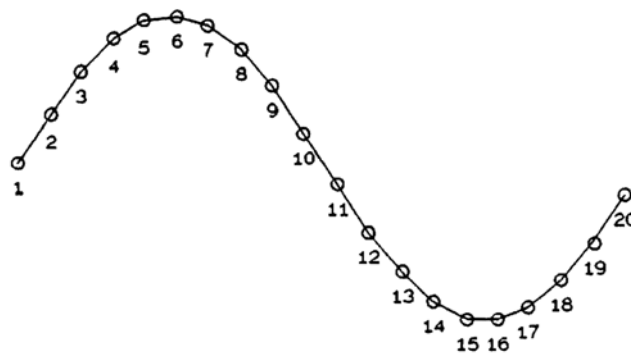


Figure 5-9 Echantillonnage direct

Remarques sur l'échantillonnage direct

- En mode Echantillonnage direct, vous ne pouvez pas utiliser la fonction de changement de gamme automatique; vous devez spécifier la gamme comme premier paramètre de la commande DSAC ou DSDC (paramètre *Entrée_max*). Les paramètres *Entrée_max* et les gammes qu'ils sélectionnent sont les suivants:

Pleine échelle			
Paramètre <i>Entrée_max</i>	Sélectionne la gamme	Format SINT	Format DINT
0 à 0,012	10 mV	12 mV	50 mV
>0,012 à 0,120	100 mV	120 mV	500 mV
>0,120 à 1,2	1 V	1,2 V	5.0 V
>1,2 à 12	10 V	12 V	50 V
>12 à 120	100 V	120 V	500 V
>120 à 1E3	1000 V	1050 V	1050 V

Lorsque vous utilisez le format de mémoire/sortie DINT, les valeurs de pleine échelle en échantillonnage direct correspondent à 500% (5 fois) des gammes de 10 m V, 100 m V, 1 V, 10V et 100V. C'est un point très important dont il faut tenir compte pour spécifier le pourcentage auquel se produira le déclenchement. Supposons par exemple que le signal d'entrée ait une valeur crête de 20V et que vous utilisiez la gamme 10V. Si vous désirez un déclenchement à 15V, spécifiez un pourcentage de déclenchement de 150% (commande LEVEL 150). (Le front de montée des amplificateurs du multimètre peut être dépassé lorsque vous mesurez un signal dont la fréquence est > 2 MHz et l'amplitude > 120% de la gamme. Les signaux > 120% de la gamme avec des fréquences jusqu'à 12 MHz ne génèrent pas d'erreur du Front de montée).

- La hiérarchie de déclenchement du multimètre (événement d'armement, de déclenchement et d'échantillonnage) s'applique à l'échantillonnage direct c'est-à-dire que ces événements doivent se produire dans le bon ordre avant que l'échantillonnage direct ne commence. Pour plus de détails sur cette hiérarchie, se reporter au [chapitre 4](#). En mode Echantillonnage direct, vous pouvez utiliser soit l'événement d'échantillonnage TIMER et la commande

NRDGS n. TIMER soit la commande SWEEP (SWEEP est plus simple à programmer). Les commandes NRDGS et SWEEP sont interchangeables et le multimètre utilise celle des deux qui a été spécifiée en dernier. (Avec la commande SWEEP, l'événement d'échantillonnage est automatiquement défini à TIMER).

- Lorsque vous échantillonnez directement un signal d'entrée dont la fréquence est ≥ 1 MHz, le premier échantillon risque d'être erroné à cause du temps d'établissement de l'interpolateur. Pour être sûr que le premier échantillon sera précis, insérez une valeur de retard de 500 ns avant le premier échantillon (commande DELAY 500E-9).

Exemple d'échantillonnage direct

Le programme suivant donne un exemple de numérisation par échantillonnage direct, à couplage CC. La commande SWEEP spécifie un intervalle de 30 μ s et 200 échantillons. Le niveau de déclenchement est défini à 250% de la gamme 10 V (250% de 10V = 25V). Les échantillons sont enregistrés en mémoire de lecture au format DINT. Les échantillons sont ensuite transmis au contrôleur, convertis et imprimés. Si vous supprimez la ligne 110, les échantillons seront directement transmis au contrôleur sans passer par la mémoire de lecture. Le contrôleur et le bus doivent toutefois pouvoir transférer des échantillons à la vitesse d'au moins 134 Ko/seconde, sinon le multimètre générera l'erreur TRIGGER TOO FAST (Déclenchement trop rapide). Pour plus de détails à ce sujet, voir [Transfert à grande vitesse par le bus GPIB in chapitre 4](#).

```

10 OPTION BASE 1                !BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Num_samples,I,J,K    !CREE LES VARIABLES ENTIERES
30 Num_samples=200              !200 ECHANTILLONS
40 ASSIGN @Dvm TO 722          !AFFECTATION DE L'ADRESSE DU MULTIMETRE
50 ASSIGN @Buffer TO BUFFER [4*Num_samples] !CONFIGURE LA
52 !MEMOIRE-TAMPON DU CONTROLEUR POUR LES ECHANTILLONS
55 !(4 OCTETS/ECHANTILLON * 200 ECHANTILLONS = 800 OCTETS)
60 ALLOCATE REAL Samp(1:Num_samples) !CREE LE TABLEAU DES REELS
65                               !POUR LES ECHANTILLONS
70 OUTPUT @Dvm;"PRESET FAST"    !FORMATS DINT, TARM SYN, TRIG AUTO
80 OUTPUT @Dvm;"SWEEP 30E-6,200" !INTERVALLE 30  $\mu$ s, 200
85                               !ECHANTILLONS
90 OUTPUT @Dvm;"DSDC 10"        !ECHANTILLONNAGE DIRECT, GAMME 10 V

```

```

100 OUTPUT @Dvm;"LEVEL 250,DC" DECLenchement A 250% DE LA GAMME (25 V)
110 OUTPUT @Dvm; "TRIG LEVEL" !EVENEMENT DE DECLenchement FAR NIVEAU
120 OUTPUT @Dvm; "MEM FIFO" !VALIDE LA MEMOIRE DE LECTURE, MODE FIFO
130 TRANSFER @Dvm TO @Buffer;WAIT !TRANSMET LES ECHANTILLONS AU
135 !CONTROLEUR
140 OUTPUT @Dvm; "ISCALE'?" !INTERROGATION DU FACTEUR D'ECHELLE FOUR
145 !LE FORMAT DINT
150 ENTER @Dvm;S !ENTRE LE FACTEUR D'ECHELLE
160 FOR I=1 TO Num_samples
170 ENTER @Buffer USING "#, W, W" ;J,K !ENTRE UN MOT DE 16 BITS
172 !NOTATION COMPLEMENT A 2 DANS CHAQUE VARIABLE J ET K ( # =
175 !FIN D'INSTRUCTION NON REQUISE; W = ENTRER DONNEES SOUS
177 !FORME D'ENTIER 16 BITS NOTATION COMPLEMENT A 2)
180 Samp(I)=(J*65536.+K+65536.*(K<0)) !CONVERSION EN NOMBRE REEL
190 R=ABS(Samp(I)) !UTILISATION DE LA VALEUR ABSOLUE FOUR
195 !VERIFIER LA SURCHARGE
200 IF R>=2147483647 THEN PRINT "OVLD" !SI SURCHARGE, IMPRESSION
205 !D'UN MESSAGE
210 Samp(I)=Samp(I)*S !APPLICATION DU FACTEUR D'ECHELLE
220 Samp(I)=DROUND(Samp(I),8) !ARRONDIT LES LECTURES CONVERTIES
230 PRINT Samp(I) !IMPRESSION DES LECTURES
240 NEXT I
250 END

```


Sous-échantillonnage

Dans le sous-échantillonnage (également connu sous le nom d'échantillonnage séquentiel), le multimètre prend un ou plusieurs échantillons sur chaque période du signal d'entrée. A chaque période, le point de départ de l'échantillon est retardé par rapport à la précédente et le nombre d'échantillons augmente. Quand le nombre d'échantillons spécifié a été atteint, ceux-ci sont reconstitués pour donner un signal composite dont la période est égale à celle du signal d'entrée.

L'avantage du sous-échantillonnage est que les échantillons peuvent être espacés à un intervalle minimal de 10 ns contre 10 μ s pour les tensions continues et 20 μ s pour l'échantillonnage direct. Ce qui signifie que le sous-échantillonnage peut être utilisé pour numériser des signaux avec des composantes de fréquence allant jusqu'à 12 MHz (largeur de bande supérieure du signal pour le sous-échantillonnage). Les mesures sous-échantillonnées utilisent l'échantillonneur-bloqueur dont le temps d'ouverture est de 2 nanosecondes. Le sous-échantillonnage (et l'échantillonnage direct) ont une instabilité de déclenchement moindre, comparée à la numérisation des tensions continues (voir ["Annexe A : Spécifications"](#) à la page 411). Les inconvénients du sous-échantillonnage sont que le signal d'entrée doit être périodique (répétitif) et que ce procédé ne permet pas les mesures en temps réel.

Vous spécifiez le sous-échantillonnage à l'aide de la commande SSAC ou SSDC. La commande SSAC sélectionne le couplage ca qui permet de ne numériser que la composante alternative du signal d'entrée. La commande SSDC sélectionne le couplage cc qui permet de numériser à la fois les composantes alternative et continue du signal d'entrée.

Principe du sous-échantillonnage

En mode sous-échantillonnage, les échantillons du signal composite peuvent être très rapprochés. Cela signifie que l'intervalle entre les échantillons (*intervalle_réel*) peut être beaucoup plus petit (et donc, la vitesse d'échantillonnage beaucoup plus rapide) que dans les mesures de tensions continues ou l'échantillonnage direct. Supposons par exemple que vous ayez besoin de numériser un signal d'entrée répétitif de 10 kHz avec un *intervalle_réel* entre les échantillons de 5 μ s. Cela donne une vitesse d'échantillonnage de 1/5E-6 soit 200 000 échantillons par seconde. (Cette vitesse est impossible à atteindre avec les tensions continues ou l'échantillonnage direct dont les vitesses d'échantillonnage maximales sont respectivement de 100 000 et de 50 000 échantillons par seconde). La [figure 5-10](#)

montre comment cette vitesse peut être obtenue avec le sous-échantillonnage. L'*intervalle_réel* est défini à $5\ \mu\text{s}$ et le nombre d'échantillons spécifiés est de 20 (commande SWEEP). Une fois l'*intervalle_réel* et le nombre total d'échantillons spécifiés, le multimètre calcule le nombre de "rafales" (une "rafale" est un groupe d'échantillons) dont il a besoin et le nombre d'échantillons qu'il placera dans chacune d'elle.

Dans cet exemple, le multimètre prend un groupe de 5 échantillons sur la première période du signal d'entrée. Sur la seconde période, il retarde le déclenchement de $5\ \mu\text{s}$ et prend un autre groupe de 5 échantillons. Sur les deux périodes suivantes, le multimètre retarde à nouveau le déclenchement de $5\ \mu\text{s}$ et reprend un groupe de 5 échantillons. Comme l'illustre la **figure 5-11**, une fois que tous les échantillons sont reclassés dans la séquence correcte, le résultat correspond à une période du signal d'entrée comportant 20 échantillons espacés de $5\ \mu\text{s}$. Dans cet exemple, la *vitesse d'échantillonnage réelle* est donc bien de 200 000 échantillons par seconde.

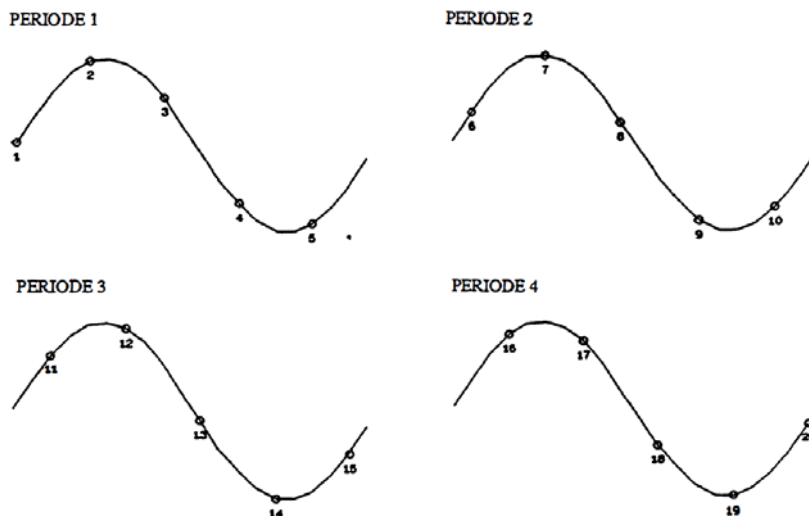


Figure 5-10 Exemple de sous-échantillonnage



Figure 5-11 Signal composite

L'événement Source de synchronisation

Le précédent exemple de sous-échantillonnage supposait que le multimètre puisse d'une façon ou d'une autre se synchroniser sur les périodes du signal d'entrée. C'est le rôle de l'événement Source de synchronisation. Vous pouvez utiliser soit l'événement EXT soit l'événement LEVEL comme source de synchronisation. L'événement EXT (spécifié par la commande SSRC EXT) se produit sur la transition négative du connecteur **Ext Trig** du multimètre. Ce qui suppose une impulsion externe synchronisée sur le signal d'entrée. La [figure 5-12](#) montre un signal d'entrée typique et le signal de synchronisation requis. Vous remarquerez que le signal de synchronisation ne doit pas nécessairement réapparaître sur chaque période du signal d'entrée. Il doit toutefois être synchronisé en temps avec le signal d'entrée.

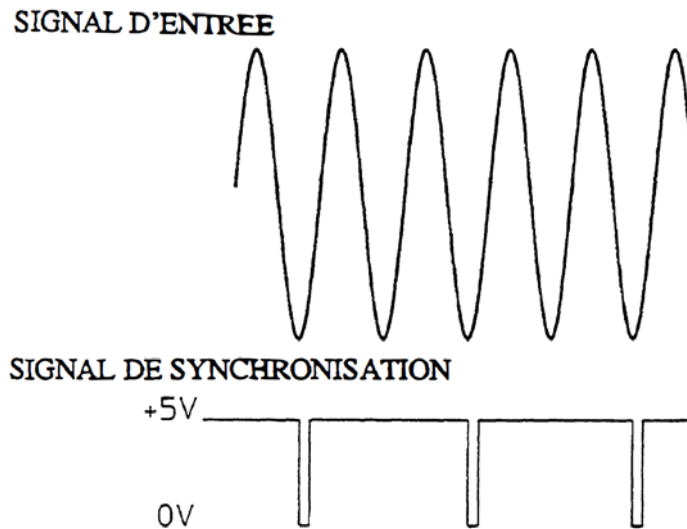


Figure 5-12 Signal de synchronisation typique pour la source sync EXT

L'événement Source de synchronisation LEVEL (qui est événement Source de synchronisation des états de mise sous tension/par défaut) se produit au passage du signal d'entrée par un niveau de tension spécifié sur la pente spécifiée (déclenchement par niveau). La [figure 5-10](#) montre comment fonctionne l'événement Source de synchronisation LEVEL (dans notre exemple, il est spécifié à 0%, pente positive et couplage CA). Le premier événement de synchronisation se produit au passage du signal d'entrée par 0 V, avec une pente positive. Le multimètre prend alors un groupe d'échantillons (5 échantillons dans ce cas). Lorsque l'événement de synchronisation se reproduit (période 2 du signal d'entrée), le multimètre retarde le déclenchement et prend 5 échantillons supplémentaires. Ce procédé se répète jusqu'à ce que le nombre d'échantillons spécifié ait été atteint.

Dans l'exemple suivant, la commande SSDC est utilisée pour numériser un signal de 1 MHz avec une valeur crête de 5V, centré sur 5 V CC. La commande SWEEP demande au multimètre de prendre 4000 échantillons avec un *intervalle_réel* de 10 nanosecondes. Les lignes 60 à 80 spécifient le niveau de tension et la pente pour l'événement Source de synchronisation LEVEL. L'échantillonnage commencera lorsque la première période du signal d'entrée atteindra 7,5 V cc (75% de la gamme 10 V). La ligne 90 satisfait l'événement d'armement de déclenchement qui valide l'événement Source de synchronisation.

```

10 OUTPUT 722;"PRESET FAST"    !TARM SYN, TRIG AUTO, FORMATS DINT
20 OUTPUT 722;"MEM FIFO"      !VALIDE LA MEMOIRE DE LECTURE. MODE FIFO
30 OUTPUT 722;"MFORMAT SINT"  !FORMAT DE LA MEMOIRE DE LECTURE: SINT
40 OUTPUT 722."SSDC 10"       !SOUS-ECHANTILLONNAGE, GAMME 10 V,
45                             !EVENEMENT SOURCE DE SYNCHRONISATION
47                             !LEVEL (EVENEMENT PAR DEFALT)
50 OUTPUT 722;"SWEEP 10E-9,4000" !4000 ECHANTILLONS, INTERVALLE
55                             !REEL DE 10 ns
60 OUTPUT 722;"LEVEL 75 DC"   !DECLenchement PAR NIVEAU A 75% DE LA
65                             !GAMME, COUPLAGE CC
70 OUTPUT 722;"SLOPE POS"     !DECLenchement SUR PENTE POSITIVE
80 OUTPUT 722;"SSRC LEVEL"    !EVENEMENT SOURCE DE SYNCHRONISATION
85                             !LEVEL
90 OUTPUT 722;"TARM SGL"      !VALIDATE L'ECHANTILLONNAGE
100 END

```

Remarques relatives au sous-échantillonnage

- En mode sous-échantillonnage, les conditions de l'événement de déclenchement et d'échantillonnage sont ignorées (ces événements sont décrits au [chapitre 4](#)). Les seuls événements de déclenchement qui s'appliquent au sous-échantillonnage sont l'événement d'armement de déclenchement (commande TARM) et l'événement Source de synchronisation (commande SSRC).
- Vous ne pouvez pas utiliser la commande NRDGS pour le sous-échantillonnage. Vous devez spécifier le nombre d'échantillons et l'*intervalle_réel* à l'aide de la commande SWEEP. L'*intervalle_réel* minimal en sous-échantillonnage est de 10 nanosecondes. La vitesse maximale à laquelle les échantillons sont pris est de 50 k échantillons par seconde (20 µs entre les échantillon).
- Vous ne pouvez pas utiliser la fonction de changement de gamme automatique pour les mesures sous-échantillonnées. Vous devez spécifier la gamme comme premier paramètre de la commande SSAC ou SSDC (paramètre *Entrée_max*). Les paramètres *Entrée_max* et les gammes qu'ils sélectionnent sont les suivants:

Paramètre Entrée_max	Sélectionne la gamme	Pleine échelle
0 à 0,012	10 mV	12 mV
>0,012 à 0,120	100 mV	120 mV
>0,120 à 1,2	1 V	1.2 V
>1,2 à 12	10 V	12 V
>12 à 120	100 V	120 V
>120 à 1E3	1000 V	1050 V

Comme pour 1 l'échantillonnage direct, vous pouvez spécifier un niveau de tension de déclenchement jusqu'à 500% de la gamme. Le format SINT (obligatoire) ne peut toutefois traiter les échantillons supérieurs à 120% de la gamme.

- Si la mémoire de lecture est invalidée lorsque vous exécutez la commande SSAC ou SSDC, le multimètre définira automatiquement le format de sortie à SINT (le format de mémoire n'est pas modifié). Si plus tard, vous changez de fonction de mesure, le format de sortie reprend sa précédente valeur. Vous devez utiliser le format de sortie SINT lorsque vous procédez à un sous-échantillonnage et que vous transmettez directement les échantillons par le bus GPIB. Vous pouvez toutefois spécifier le format de sortie de votre choix si les échantillons sont d'abord placés en mémoire de lecture (voir remarque suivante). Pour ce faire, vous devez valider la mémoire de lecture avant d'exécuter la commande SSAC ou SSDC (l'exécution de l'une ou l'autre de ces commandes ne convertit pas le format de sortie à SINT si la mémoire de lecture est validée).
- Si vous procédez à un sous-échantillonnage avec la mémoire de lecture validée, celle-ci doit être en mode FIFO et vide (l'exécution de la commande MEM FIFO efface le contenu de la mémoire de lecture). D'autre pan, le format de mémoire doit être défini à SINT avant que l'événement d'armement de déclenchement ne se produise. Dans le cas contraire, le multimètre génère l'erreur SETTINGS CONFLICT (Conflit de configurations) lorsque l'événement d'armement de déclenchement se produit et aucun échantillon n'est pris.
- Lorsque vous sous-échantillonnez un signal d'entrée dont la fréquence est ≥ 1 MHz, le premier échantillon peut être erroné à cause du temps d'établissement de l'interpolateur. Pour que le premier échantillon soit précis, vous devez

spécifier une valeur de retard de 500 ns à l'aide de la commande DELAY 500E-9. (En mode sous-échantillonnage, la valeur de retard est insérée entre l'événement Source de synchronisation et le premier échantillon de chaque groupe; la valeur de retard par défaut pour le sous-échantillonnage est de 0 seconde).

Transfert des échantillons en mémoire

Lorsque les échantillons sont directement transférés en mémoire de lecture (commande MEM FIFO), le multimètre les re-classe automatiquement pour produire un signal composite. Dans le programme suivant par exemple, les données sous-échantillonnées sont enregistrées en mémoire de lecture sous le format SINT (obligatoire). Le multimètre place les échantillons en mémoire dans l'ordre correct. Les échantillons sont ensuite transmis au contrôleur sous le format de sortie DREAL (lorsque vous placez d'abord les échantillons en mémoire de lecture, le format de sortie n'est plus limité à SINT).

```

10 OPTION BASE 1                !BORNE INFERIEURE DU TABLEAU A 1
20 REAL Samp(1:200) BUFFER      !CREE UN TABLEAU EN MEMOIRE-TAMPON
30 ASSIGN @Dvm TO 722           !AFFECTATION DE L'ADRESSE DU MULTIMETRE
40 ASSIGN @Samp TO BUFFER Samp(*) !AFFECTATION DE LA
45                               !MEMOIRE-TAMPON
50 OUTPUT @Dvm;"PRESET FAST"    !TARM SYN, TRIG AUTO, FORMATS DINT
60 OUTPUT @Dvm;"MEM FIFO"       !VALIDE LA MEMOIRE DE LECTURE, MODE FIFO
70 OUTPUT @Dvm;"MFORMAT SINT"   !FORMAT DE LA MEMOIRE DE LECTURE: SINT
80 OUTPUT @Dvm;"OFORMAT DREAL"  !FORMAT DE SORTIE : REEL LONG
90 OUTPUT @Dvm;"SSDC 10"        !SOUS-ECHANTILLONNAGE, GAMME 10 V,
95                               !COUPLAGE CC
100 OUTPUT @Dvm;"SWEEP 5E-6,200" !200 ECHANTILLONS, INTERVALLE REEL
105                               DE 5 µs
110 TRANSFER @Dvm TO @Samp;WAIT !TRANSFERT DES ECHANTILLONS DANS LA
115                               !MEMOIRE-TAMPON DU CONTROLEUR
120 FOR I=1 TO 200
130 IF ABS(Samp(I))=1E+38 THEN !DETECTION D'UNE SURCHARGE
140 PRINT "condition de surcharge" !IMPRIME UN MESSAGE DE SURCHARGE
150 ELSE                         !EN L'ABSENCE DE SURCHARGE
160 Samp(I)=DROUND(Samp(I),5) !ARRONDIT A 5 CHIFFRES
170 PRINT Samp(I)              !IMPRIME CHAQUE ECHANTILLON

```

```

180 END IF
190 NEXT I
200 END

```

Envoi des échantillons au contrôleur

Lorsque les échantillons sont directement transmis au contrôleur, un algorithme doit être utilisé pour re-classer les échantillons et produire la forme d'onde composite. La commande d'interrogation SSPARM? renvoie les trois paramètres de l'algorithme. Le premier paramètre renvoie est le nombre de "rafales" qui contenait N échantillons. Le second paramètre renvoie est le nombre de "rafales" qui contenait N-1 échantillons. Le troisième paramètre renvoie est la valeur N. Supposons par exemple que vous sous-échantillonnez un signal de 10 kHz et que vous avez spécifié 22 échantillons séparés par un *intervalle_réel* de 5 µs. Dans cet exemple, le multimètre prend deux groupes ("rafales") de 6 échantillons chaque et 2 groupes de 5 échantillons. Chaque groupe mesure est retardé de 5 µs par rapport au précédent. Les valeurs retournées par la commande SSP ARM? sont alors 2, 2 et 6.

En mode sous-échantillonnage, la vitesse d'échantillonnage maximale est de 50 k échantillons par seconde, quel que soit l'*intervalle_réel* spécifié. (Si vous spécifiez un *intervalle_réel* de ≥ 20 µs, le multimètre ne procède plus à un sous-échantillonnage mais à un échantillonnage direct). Lorsque vous transférez directement des échantillons au contrôleur (en utilisant le format SINT (obligatoire) qui correspond à 2 octets par échantillon), le bus GPIB/contrôleur doit être capable de traiter les données à une vitesse maximale de 100 Ko par seconde. Si tel n'est pas le cas, le multimètre génèrera l'erreur TRIGGER TOO FAST (Déclenchement trop rapide).

Dans le programme suivant, la commande SSAC est utilisée pour numériser un signal de 10 kHz avec une valeur crête de 5 V. La commande SWEEP demande au multimètre de prendre 1000 échantillons (variable Num_samples) avec un *intervalle_réel* de 2 µs (variable Eff_int). La mesure utilise le niveau de déclenchement par défaut pour l'événement Source de synchronisation (déclenchement sur le signal d'entrée, 0%, couplage CA, pente positive). La ligne 110 génère un événement SYN et transfère directement les échantillons dans l'ordinateur. Les lignes 230 à 400 trient les données sous-échantillonnées pour produire le signal composite. Celui-ci est sauvegardé dans le tableau Wave_form.


```

10 OPTION BASE 1                !BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Num_samples,Inc,I,J,K,L !DECLARATION DES VARIABLES
30 Num_samples=1000             !NOMBRE D'ECHANTILLONS = 1000
40 Eff_int=2.0E-6                !SPECIFICATION DE L'INTERVALLE_REEL
50 INTEGER Int samp(1:1000) BUFFER !CREE LE TABLEAU DES ENTÎERS EN
55                               !MEMOIRE-TAMPON
60 ALLOCATE REAL Wave_form(1:Num_samples) !CREE UN TABLEAU POUR
65                               !LES DONNEES TRIEES
70 ALLOCATE REAL Samp(1:Num_samples) !CREE UN TABLEAU POUR LES
75                               !ECHANTILLONS
80 ASSIGN @Dvm TO 722            !AFFECTATION DE L'ADRESSE OU MULTIMETRE
90 ASSIGN @Int_samp TO BUFFER Int_samp(*) !AFFECTATION DU NOM
95                               !D'ACCES A LA MEMOIRE-TAMPON
100 OUTPUT @Dvm;"PRESET FAST;LEVEL;SLOPE;SSOC 10;SWEEP";Eff_int,
    Num_samples

102 !MESURES RAPIDES, TARM SYN, NIVEAU & PENTE PAR DEFAULT,
105 !SOUS-ECHANTILLONNAGE (FORMAT DE SORTIE SINT), GAMME 10 V,
107 !INTERVALLE REEL 2 µs, 1000 ECHANTILLONS
110 TRANSFER @Dvm TO @Int_samp;WAIT ! EVENEMENT SYNCHRONE,
111 !TRANSFERT DES LECTURES DANS LE TABLEAU DES ENTIERS DE
112 !L'ORDINATEUR; PAS DE CONVERSION DE DONNEES REQUISES PUISQUE
115 !LE FORMAT INTEGER DE L'ORDINATEUR EST IDENTIQUE A SINT (MAIS
117 !TABLEAUX DES ENTIERS REQUIS)
120 OUTPUT @Dvm; "I SCALE?"      !INTERROGATION DU FACTEUR D'ECHELLE POUR
125                               !LE FORMAT SINT
130 ENTER @Dvm;S                 !ENTRE LE FACTEUR D'ECHELLE
140 OUTPUT @Dvm;"SSPARM?"       !INTERROGATION DES PARAMETRES DE SOUS-
145                               !ECHANTILLONNAGE
150 ENTER @Dvm;N1, N2, N3!ENTRE LES PARAMETRES DE SOUS-ECHANTILLONNAGE
160 FOR I=1 TO Num_samples
170 Samp(I) = Int_samp(I)        !CONVERSION DE CHAQUE LECTURE OU FORMAT
175 !ENTIER AU FORMAT REEL (OBLIGATOIRE POUR EVITER UN
177 !DEPASSEMENT ENTIER SUR LA LIGNE SUIVANTE)
180 R=ABS(Samp(I))               !UTILISATION DE LA VALEUR ABSOLUE POUR
185                               !VERIFIER SURCHARGE
190 IF R>=32767 THEN PRINT "OVLD" !SI SURCHARGE, IMPRESSION D'UN

```

```

195                                     !MESSAGE
200 Samp(I)=Samp(I)*S                 !MULTIPLICATION DE LA LECTURE PAR LE
205                                     !FACTEUR D'ECHELLE
210 Samp(I)=DROUND(Samp(I),4) !VALEUR ARRONDIE A 4 CHIFFRES
220 NEXT I
225 !-----TRI DES ECHANTILLONS-----
230 Inc=N1+N2                         !NOMBRE TOTAL DE RAFALES
240 K=1
250 FOR I=1 TO N1
260 L=1
270 FOR J=1 TO N3
280 Wave_form(L)=Samp(K)
290 K=K+1
300 L=L+Inc
310 NEXT J
320 NEXT I
330 FOR I=N1+1 TO N1+N2
340 L=I
350 FOR J=1 TO N3-1
360 Wave_form(L)=Samp(K)
370 K=K+1
380 L=L+Inc
390 NEXT J
400 NEXT I
410 END

```

Visualisation des données échantillonnées

Le programme de la page suivante trace les données numérisées sur l'écran du contrôleur (ce programme particulier utilise le sous-échantillonnage et la sous-routine *Plot_it* effectue le traçage proprement dit). Ce programme peut s'avérer utile lorsque vous développez des programmes de numérisation (surtout par sous-échantillonnage) car il vous permet de visualiser les données recueillies. Comme ce programme se limite à tracer des vecteurs entre les échantillons (interpolation linéaire), il fonctionne bien lorsque la vitesse d'échantillonnage est supérieure à 10 fois la fréquence du signal mesuré. Dans le cas contraire, ce programme représentera le signal d'entrée d'une façon incorrecte. La [figure 5-13](#) montre un tracé typique fourni par ce programme.

REMARQUE

La bibliothèque d'analyse de signaux du Keysight 3458A option 005 est un progiciel conçu pour saisir et traiter des données numérisées. Il renferme des routines qui initialisent le système, saisissent les données, les comparent entre elles, calculent les paramètres sur les données, procèdent à des transformées de Fourier sur les données et tracent ou sortent les données. Pour plus de détails sur ce progiciel, prenez contact avec votre bureau commercial Keysight Technologies.

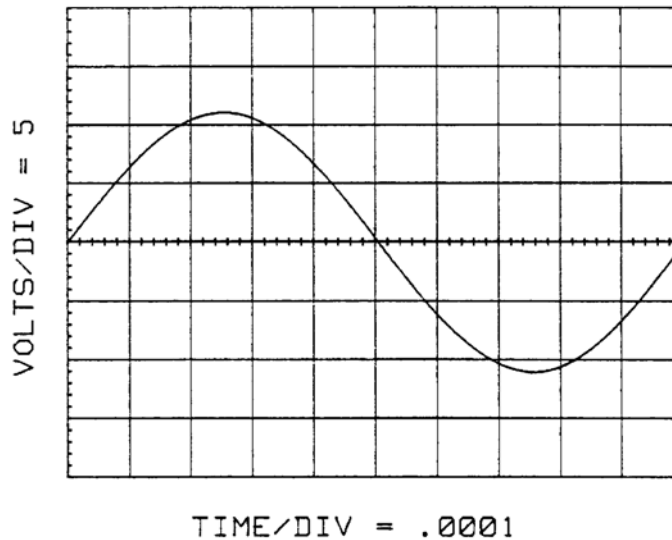


Figure 5-13 Tracé d'un signal typique

```

10 OPTION BASE 1                !BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Num_samples,Inc,I,J,K,L !DECLARATION DES VARIABLES
30 INTEGER Int_samp(1:1000) BUFFER !CREE LE TABLEAU DES ENTIERS EN
35                               !MEMOIRE-TAMPON
40 ALLOCATE REAL Wave_form(1:Num_samples)!CREE UN TABLEAU POUR
45                               !LES DONNEES TRIEES
50 ALLOCATE REAL Samp(1:Num_samples) !CREE UN TABLEAU POUR LES
55                               !ECHANTILLONS
60 Num_samples=1000             !NOMBRE D'ECHANTILLONS = 1000
70 Eff_int=2.0E-6               !SPECIFICATION DE L'INTERVALLE_REEL
80 ASSIGN @Dvm TO 722           !AFFECTATION DE L'ADRESSE OU MULTIMETRE
90 ASSIGN @Int_samp TO BUFFER Int_samp(*)!AFFECTATION DU NOM
95                               !D'ACCES A LA MEMOIRE-TAMPON
100 OUTPUT @Dvm;"PRESET FAST;LEVEL;SLOPE;SSOC 10;SWEEP";Eff_int,
    Num_samples
102 !MESURES RAPIDES, TARM SYN, SOUS-ECHANTILLONNAGE (FORMAT DE

```

```

105 !SORTIE SINT), GAMME 10 V, INTERVALLE REEL 2  $\mu$ s, 1000
107 !ECHANTILLONS
110 TRANSFER @Dvm TO @Int_samp;WAIT ! EVENEMENT SYNCHROME,
111                                !TRANSFERT DES LECTURES
120 OUTPUT @Dvm; "I SCALE?"      !INTERROGATION DU FACTEUR D'ECHELLE
125                                !POUR LE FORMAT SINT
130 ENTER @Dvm;S                  !ENTRE LE FACTEUR D'ECHELLE
140 OUTPUT @Dvm;"SSPARM?"        !INTERROGATION DES PARAMETRES DE SOUS-
145                                !ECHANTILLONNAGE
150 ENTER @Dvm;N1, N2, N3        !ENTRE LES PARAMETRES DE SOUS-
155                                !ECHANTILLONNAGE
160 FOR I=1 TO Num_samples
170 Samp(I) = Int_samp(I)        !CONVERSION DE CHAQUE LECTURE OU FORMAT
175 !ENTIER AU FORMAT REEL (OBLIGATOIRE POUR EVITER UN
177 !DEPASSEMENT ENTIER SUR LA LIGNE SUIVANTE)
180 R=ABS(Samp(I))                !UTILISATION DE LA VALEUR ABSOLUE POUR
185                                !VERIFIER SURCHARGE
190 IF R>=32767 THEN PRINT "OVLD" !SI SURCHARGE, IMPRESSION D'UN
195                                !MESSAGE
200 Samp(I)=Samp(I)*S             !MULTIPLICATION DE LA LECTURE PAR LE
205                                !FACTEUR D'ECHELLE
210 Samp(I)=DROUND(Samp(I),4)    !VALEUR ARRONDIE A 4 CHIFFRES
220 NEXT I
230 Inc=N1+N2                     !INC=NOMBRE TOTAL DE RAFALES
240 K=1                           !TRI DES ECHANTILLONS
250 FOR I=1 TO N1                 ! "
260 L=1                           ! "
270 FOR J=1 TO N3                 ! "
280 Wave_form(L)=Samp(K)         ! "
290 K=K+1                        ! "
300 L=L+Inc                      ! "
310 NEXT J                       ! "
320 NEXT I                       ! "
330 FOR I=N1+1 TO N1+N2         ! "
340 L=I                          ! "
350 FOR J=1 TO N3-1             ! "
360 Wave_form(L)=Samp(K)        ! "

```

```

370 K=K+1                ! "
380 L=L+Inc              ! "
390 NEXT J                ! "
400 NEXT I                ! "
410 DISP                 !EFFACE L'ECRAN DU CONTROLEUR
420 Time_div=1.0E-5      !TEMPS PAR DIVISION POUR TRACAGE
430 Volts_div=5           !VOLTS PAR DIVISION POUR TRACAGE
440 Plot_it(Time_div,Volts_div,Wave_form(*),Eff_int)
450 END
460 SUB Plot_it(Time_div,Volts_div,Wave_form(*),Time_base)
470 DIM X_axis$(80),Y_axis$(80)
480 GINIT
490 GRAPHICS ON
500 RAD
510 MOVE 35,10
520 LDIR 0
530 X_axis$="TIME/DIV = "&VAL$(Time_div)
540 LABEL X_axis$
550 MOVE 15,35
560 LDIR PI/2
570 Y_axis$="VOLTS/DIV = "&VAL$(Volts_div)
580 LABEL Y_axis$
590 VIEWPORT 20,110,20,90
600 WINDOW 0,10*Time_div,-4*Volts_div,4*Volts_div
610 AXES Time_div/5,Volts_div/5,0,0,1,1,1
620 GRID Time_div,Volts_div
630 Wave x=0
640 MOVE Wave_x,Wave_form(BASE(Wav_form,1))
650 FOR Wave_y=BASE(Wave_form,1)+1 TO SIZE(Wave_form,1)-1+BASE
(Wave_form,1)
660 Wave_x=Wave_x+Time_base
670 DRAW Wave_x,Wave_form(Wave_y)
680 NEXT Wave_y
690 IF Wave_x>10*Time_div THEN DISP "More samples taken than
displayed"
700 SUBEND

```

6 Référence

Introduction	244
Commandes par groupe fonctionnel	252
Commandes et fonctions de mesure	254

Introduction

La première partie de ce chapitre décrit le langage du multimètre: les commandes de base, l'envoi des commandes, les paramètres, les commandes d'interrogation, les commandes regroupées par groupe fonctionnel et un tableau de commandes seulement applicables à certaines fonctions de mesure. Le reste du chapitre contient la description détaillée de chaque commande (classement par ordre alphabétique).

Avant de lire de chapitre, il est conseillé de se reporter aux fonctions du multimètre dont vous avez besoin et dont la description figure dans les chapitres 2, 3, 4 ou 5. Les commandes présentées dans ces chapitres sont décrites en détail dans le présent chapitre où elles sont présentées au format suivant.

Nom de la commande	BEEP	
Description de la commande	Description	La commande BEEP contrôle l'indicateur sonore du 3458A. S'il est validé, cet indicateur signale les situations d'erreur par une tonalité de 1 kHz.
Syntaxe indique le format et les paramètres de la commande. Les paramètres figurant [entre crochets] sont optionnels (ont des valeurs par défaut). Les paramètres qui ne figurent pas entre crochets n'ont pas de valeurs par défaut et doivent être spécifiés.	Syntaxe	BEEP [<i>contrôle</i>]
Paramètres décrit les choix de paramètres ou gammes.	Contrôle	Les valeurs possibles du paramètre <i>contrôle</i> sont :
Valeur à la mise sous tension montre le paramètre utilisé à la mise sous tension.	Points importants	<i>Contrôle</i> à la mise sous tension = dernière valeur programmée.
Valeur par défaut montre le paramètre utilisé si vous ne spécifiez pas de paramètre.		<i>Contrôle</i> par défaut = ONCE.
Points importants présente des informations particulières sur la commande.	Points importants	● Le 3458A enregistre la valeur de <i>contrôle</i> en mémoire non-volatile (la valeur n'est pas perdue à l'arrêt de l'instrument). ● Commande d'interrogation. La commande d'interrogation BEEP? retourne le mode courant de l'indicateur sonore. Pour plus de détails sur les commandes d'interrogation, se reporter au début du présent chapitre. ● Commande connexe : TONE
Les exemples montrent des programmes ou des instructions en BASIC typiques (HP 3458A à l'adresse 722). Ces programmes s'appliquent aux ordinateurs HP série 200/300.	Exemple	<pre>OUTPUT 722: "BEEP OFF" ! INVALIDE L'INDICATEUR SONORE</pre>

Langage du multimètre

Le multimètre utilise un langage connu sous le nom de HPML (Langage des multimètres Hewlett-Packard). HPML est organisé autour d'un jeu de commandes de base qui satisfont, à elles seules, un grand nombre d'applications. Ce jeu de base se compose de 8 commandes sans compter les commandes relatives aux fonctions de mesure (FUNC, ACV, DCI, etc.). Tous les multimètres Keysight récents acceptent ces 8 commandes et les commandes de fonction correspondant à leurs possibilités. Ces 8 commandes de base sont.

```
RESET -- Place le multimètre en état de mise sous tension
PRESET -- Place le multimètre en état de préconfiguration qui facilite
les configurations ultérieures
ID? -- Renvoie le numéro de modèle du multimètre
TEST -- Exécute le test automatique
ERR? -- Lit le registre d'erreur
STB? -- Lit le registre d'état
TRIG -- Sélectionne l'événement de déclenchement
NPLC -- Sélectionne le temps d'intégration
```

Les commandes de fonctions de mesure du 3458A sont décrites dans ce chapitre sous la commande FUNC.

Le jeu de commandes HPML complet étend les capacités du multimètre bien au-delà des commandes de base mentionnées ci-dessus. Si toutefois la compatibilité de votre multimètre avec d'autres multimètres Hewlett-Packard constitue un facteur critique pour vos applications, il est conseillé de n'utiliser que les commandes de base et les commandes GPIB figurant en [annexe B](#).

Conventions de langage

Le multimètre communique avec un contrôleur système parle bus GPIB. Chaque instrument raccordé au bus a une adresse unique. Les exemples figurant dans ce manuel sont destinés à des ordinateurs Hewlett-Packard série 200/300 utilisant le langage HP BASIC. Ils supposent que le code de sélection de l'interface est à 7, l'adresse du multimètre à 22 (réglage usine), ce qui donne l'adresse GPIB 722. Nous vous recommandons de conserver cette adresse pour simplifier la programmation.

Envoi des commandes

Les délimiteurs (*cr*) (retour chariot), (*lf*) (saut de ligne),; (point-virgule) ou EOI indiquent la fin d'un message au 3458A. Quand vous envoyez une commande en utilisant le format standard (par ex, OUTPUT 722;"TEST"), l'ordinateur envoie *cr lf* (retour chariot, saut de ligne) sur le bus de données après la commande. Avec sa mémoire tampon d'entrée hors fonction, le 3458A traite le *cr* immédiatement mais ne traite pas le *lf* tant que la commande n'est pas exécutée. Cela signifie que, du fait du *lf*, le bus reste bloqué et vous ne pouvez reprendre le contrôle de l'ordinateur tant que la commande n'est pas exécutée (ou que vous envoyez la commande GPIB CLEAR qui annule l'exécution de la commande. Vous pouvez éviter ce problème en supprimant *cr lf* quand vous envoyez la commande ou en validant la mémoire-tampon d'entrée (commande INBUF ON). L'exemple ci-dessous montre comment utiliser des spécificateurs d'images (#,K) pour supprimer le *cr lf* quand vous envoyez la commande TEST.

```
OUTPUT 722 USING "#,K";"TEST;"
```

REMARQUE

Les spécificateurs d'image # et K s'appliquent aux ordinateurs HP série 200/300. Si vous disposez d'un autre ordinateur, reportez-vous à son manuel de fonctionnement pour savoir comment il supprime *cr lf*. Le point-virgule après TEST indique la fin de la commande au multimètre et doit être présent si vous supprimez la *cr lf*.

Commandes multiples

Plusieurs commandes séparées par des points-virgules peuvent être utilisées dans une chaîne de commandes. Par exemple:

```
OUTPUT 722; "TRIG HOLD;DCV 3;NPLC 10"
```

Paramètres

Les nombres utilisés comme paramètres peuvent être en format entier, virgule flottante ou exponentiel. Les nombres en format virgule flottante, cependant, sont arrondis à l'entier le plus proche si la commande attend un entier. Par exemple, "SUB 2.49" est arrondi à "SUB 2" et "SUB 2.5" à "SUB 3".

Choix des paramètres par défaut

Vous choisissez un paramètre par défaut en l'omettant ou en le remplaçant par - 1 (moins 1). Par exemple, pour spécifier 10 comme premier paramètre et choisir la valeur par défaut pour le second, envoyez:

```
OUTPUT 722;"ACV 10"
```

ou

```
OUTPUT 722;"ACV 10,-1"
```

A distance uniquement, vous pouvez utiliser 2 virgules pour indiquer une valeur par défaut. Par exemple, pour spécifier 10 comme premier paramètre et choisir la valeur par défaut pour le second, envoyez:

```
OUTPUT 722;"ACV 10,, "
```

Pour prendre le premier paramètre par défaut et spécifier .01 comme deuxième paramètre envoyez:

```
OUTPUT 722; "ACV,,.01"
```

Commandes d'interrogation

Une commande d'interrogation se termine par un point d'interrogation et renvoie une ou plusieurs réponses à une question particulière. La commande d'interrogation ID? (Identification?) par exemple renvoie la réponse *Keysight 3458A*.

Questions standard

Les commandes d'interrogation suivantes sont décrites individuellement dans ce chapitre:

AUXERR?	LINE?
CALNUM?	MCOUNT?
ERR?	OPT?
ERRSTR?	REV?
ID?	SSPARM?
ISCALE?	STB?
TEMP?	

Questions supplémentaires

Outre les questions standard ci-dessus, vous pouvez en créer d'autres en ajoutant un point d'interrogation à la fin de toute commande servant normalement à configurer ou à programmer le multimètre. (Les commandes d'interrogation de ce type ne sont pas décrites dans ce chapitre. Elles figurent cependant avec les commandes auxquelles elles se rapportent. La page consacrée à la commande AZERO par exemple mentionne à la fois AZERO et AZERO?). Pour garder notre exemple, la commande AZERO valide ou invalide la fonction d'auto-zéro. Les modes possibles sont: OFF (invalidée), ON (validée) ou ONCE (une fois). Pour connaître le mode d'auto-zéro courant, il suffit d'ajouter un point d'interrogation à la suite de la commande AZERO comme le montre le programme suivant:

```
10 OUTPUT 722;"AZERO?"
20 ENTER 722;A$
30 PRINT A$
40 END
```

Dans l'état de mise sous tension, le multimètre retourne des réponses numériques aux commandes d'interrogation. Le programme ci-dessus peut renvoyer 1 qui est l'équivalent numérique du paramètre ON (fonction validée). L'équivalent

numérique des paramètres est indiqué pour chacune des commandes (si applicable).

Pour les commandes qui offrent un choix de paramètres (telles que la commande AZERO), la commande d'interrogation leur correspondant renvoient le choix couramment spécifié (ou son équivalent numérique). De nombreuses commandes utilisent les valeurs couramment spécifiées en secondes, volts, ohms, etc. en place du paramètre. La commande APER par exemple spécifie le temps d'intégration en secondes. La gamme des valeurs de cette commande va de 500 ns à 1 s. Lorsque vous envoyez la commande d'interrogation APER?, le multimètre renvoie la valeur réelle du temps d'intégration couramment spécifié.

La commande QFORMAT peut être utilisée pour spécifier le format de la réponse à une interrogation: réponse numérique (illustrée ci-dessus), réponse alphabétique ou alphanumérique. Le programme suivant par exemple spécifie un format de réponse ALPHA. Dans ce cas, le multimètre renvoie l'en-tête de la commande et une réponse alphanumérique (si possible) comme l'illustre le programme ci-dessous.

```
10 OUTPUT 722;"QFORMAT ALPHA"
20 OUTPUT 722;"AZERO?"
30 ENTER 722;A$
40 PRINT A$
50 END
```

Réponse typique: AZERO ON

Avec le format ALPHA, les commandes qui utilisent normalement des valeurs numériques renvoient un en-tête de commande alphabétique et une réponse numérique. Une réponse typique à la commande d'interrogation APER? sera par exemple:

```
APER 166.667E-03
```

De nombreuses commandes d'interrogation peuvent renvoyer des réponses à la fois alphabétiques et numériques. La commande d'interrogation NRDGS? par exemple renvoie deux réponses. La première est une valeur numérique indiquant le nombre de lectures par déclenchement; la seconde est une réponse alphabétique (à condition que QFORMAT = ALPHA), qui indique l'événement d'échantillonnage spécifié. Le programme suivant exécute la commande d'interrogation NRDGS? et imprime les réponses.

```
10 OUTPUT 722;"NRDGS?"
20 ENTER 722;A$,B$
```

```
30 PRINT A$,B$  
40 END
```

Les réponses aux commandes d'interrogation sont toujours transmises par le bus GPIB au format de sortie ASCII, quel que soit le format de sortie spécifié. Dès que la réponse à une interrogation est reçue, le format de sortie revient au format précédemment spécifié (SINT, DINT, SREAL, DREAL ou ASCII).

Commandes par groupe fonctionnel

La liste suivante regroupe les commandes reconnues par le multimètre par fonction (fonctions de mesure, numérisation, convertisseur A/N, etc.).

Fonctions de mesure

ACDCI
ACDCV
ACI
ACV
DCI
DCV
DSAC
DSDC
FREQ
FUNC
OHM
OHMF
PER
SSAC
SSDC

Mesure connexe

ACBAND
ARANGE
AZERO
DELAY
FIXEDZ
FSOURCE
LFILTER
OCOMP
PRESET (DIG, FAST, ou NORM)
RANGE ou R
RATIO
SETACV
SSPARM?
TERM

Numérisation

DSAC
DSDC
LEVEL
LFILTER
SLOPE
NRDGS
PRESET (DIG & FAST)
SSAC
SSDC
SSPARM?
SSRC
SWEEP
TIMER

Déclenchement

EXTOUT
LEVEL
LFILTER
NRDGS
SLOPE
SSRC
SWEEP
TARM
TBUF
TIMER
TRIG ou T

Mémoire de lecture

MCOUNT?
MEM
MFORMAT
MSIZE
RMEM

Mémoire de sous-programme

CALL
COMPRESS
CONT
DELSUB
PAUSE
SCRATCH
SUB
SUBEND

Mémoire d'état

PURGE
RSTATE
SCRATCH
SSTATE

Convertisseur A/N

APER
LFREQ
LINE?
NPLC
RES

Etat

CSB
RQS
SRQ
STB?

Entrée/Sortie

END
INBUF
ISCALE?
OFORMAT
QFORMAT

Erreurs

AUXERR?
EMASK
ERR?
ERRSTR?

Math

MATH
MMATH
RMATH
SMATH

Clavier

DEFKEY
LOCK
MENU

Bus

ADDRESS
ID?
SRQ

Système

BEEP
DEFEAT
EXTOUT
OPT?
PRESET (DIG, FAST, ou NORM)
QFORMAT
RESET
TONE

Affichage

DISP
NDIG

Etalonnage/Test

ACAL
CAL
CAL?
CALNUM?
CALSTR
REV?
SCAL
SECURE
TEMP?
TEST

Commandes GPIB

ABORT IO
CLEAR
LOCAL
LOCAL LOCKOUT
REMOTE
SPOLL
TRIGGER

Commandes et fonctions de mesure

Le **tableau 6-1** montre les commandes du multimètre qui ne s'appliquent qu'à certaines fonctions de mesure. Le point (●) indique que la commande s'applique sans restrictions. Un chiffre (1-5) indique que la commande est limitative (voir notes numérotées au bas du tableau). Un blanc indique que la commande ne s'applique pas à la fonction de mesure. Les commandes du multimètre ne figurant pas dans ce tableau s'appliquent à toutes les fonctions de mesure sans restrictions.

Tableau 6-1 Commandes et fonctions de mesure

	DCV	DCI	OHM OHMF	ACV ACDCV (ANA)	ACV ACDCV (SYNC)	ACV ACDCV (RNDM)	ACI ACDCI	FREQ PER	DSAC DSDC	SSAC SSDC
ACBAND				●	●	●	●	●		
APER	●	●	●	●			●			
ARANGE ¹	●	●	●	●	●	●	●	●		
AZERO	●	●	●							
FIXEDZ	●		●							
FSOURCE								●		
ISCALE?	●	●	●	●	●	●	●	1	●	●
LEVEL	●				2			3	●	●
LFILTER	●				●			●	●	●
LFREQ	●	●	●	●			●			
(M) MATH ¹	●	●	●	●	●	●	●	●	●	4
MFORMAT	●	●	●	●	●	●	●	1	●	5
NPLC	●	●	●	●			●			
OCOMP			●							
OFORMAT	●	●	●	●	●	●	●	1	●	5
RATIO	●			●	●	●				

Tableau 6-1 Commandes et fonctions de mesure

	DCV	DCI	OHM OHMF	ACV ACDCV (ANA)	ACV ACDCV (SYNC)	ACV ACDCV (RNDM)	ACI ACDCI	FREQ PER	DSAC DSDC	SSAC SSDC
SETACV				●	●	●				
SLOPE	●				2			3	●	●
SSPARM?										●
SSRC					●					●
SWEEP	●	●	●	●			●		●	●
TIMER	●	●	●	●			●		●	

- 1 Le format de mémoire/sortie SINT ou DINT n'est pas conseillé pour les mesures FREQ ou PER; lorsqu'une opération mathématique en temps réel ou différée est validée (à l'exception de STAT et de PFAIL); ou encore lorsque la fonction de changement de gamme automatique est validée.
- 2 Le déclenchement par niveau est l'événement Source de synchronisation par défaut des mesures de tension alternative ou alternative + continue effectuées par la méthode analogique. Le niveau de la tension de déclenchement et la pente sont toutefois déterminés automatiquement et ne peuvent pas être spécifiés.
- 3 Vous ne pouvez pas utiliser l'événement de déclenchement ou d'échantillonnage LEVEL pour les mesures FREQ et PER. Vous pouvez cependant spécifier le niveau de tension et la pente que les circuits de détection de niveau utiliseront pour mesurer la fréquence ou la période.
- 4 Vous ne pouvez pas utiliser la commande MATH en mode de sous-échantillonnage. Mais vous pouvez utiliser la commande MMATH.
- 5 Pour le sous-échantillonnage, si vous utilisez la mémoire de lecture, le format de mémoire doit impérativement être à SINT. Si vous n'utilisez pas la mémoire de lecture, le format de sortie doit être spécifié à SINT.

ACAL

Autocal. La commande ACAL demande au multimètre d'effectuer un ou tous ses étalonnages automatiques.

Syntaxe

ACAL [*type*][*,code de sécurité*]

type Les choix de paramètre *type* sont:

Paramètre <i>type</i>	Équivalent numérique	Description
ALL	0	Effectue les étalonnages automatique DCV, OHMS et AC
DCV	1	Étalonnage du gain et du décalage de tension cc (voir premier Point important)
AC	2	Étalonnage de la linéarité, du gain et du décalage ca (voir deuxième Point important)
OHMS	4	Étalonnage du gain et du décalage de résistance (voir troisième Point important)

Type à la mise sous tension = sans

Type par défaut = ALL

code de sécurité Lorsque la fonction d'étalonnage automatique est protégée, vous devez spécifier le code de sécurité lui correspondant avant de procéder à l'étalonnage automatique. Si la fonction n'est pas protégée (elle ne l'est pas lorsque le multimètre est expédié de l'usine), vous n'avez aucun code à spécifier. Pour plus de détails sur le code de sécurité et sur la façon de protéger la fonction d'étalonnage automatique, se reporter à la commande **SECURE**.

Points importants

- Comme l'étalonnage automatique DCV s'applique à toutes les fonctions de mesure, vous devez l'effectuer avant d'effectuer l'étalonnage automatique AC ou OHMS. Lorsque ACA ALL est spécifié, l'étalonnage DCV est effectué avant tout autre étalonnage.

- Pour une précision maximale, il est conseillé d'effectuer ACAL ALL toutes les 24 heures ou dès que la température du multimètre change de $\pm 1^\circ$ par rapport au dernier étalonnage externe ou au dernier étalonnage automatique. (Il est recommandé de sauvegarder la température d'étalonnage interne du multimètre à l'aide de la commande CALSTR: vous pourrez ainsi la relire plus tard à l'aide de la commande CALSTR? et constatez les éventuelles variations).
- L'étalonnage automatique AC augmente la précision à court terme des mesures de tension alternative et alternative + continue (quelle que soit la méthode de mesure), de courant alternatif et alternatif + continu, d'échantillonnage direct, de sous-échantillonnage ainsi que la précision à court terme des mesures de fréquence et de période.
- L'étalonnage automatique OHMS augmente la précision à court terme des mesures de résistance 2- ou 4-fils et des mesures de courant alternatif et continu.
- Déconnectez toujours tous les signaux d'entrée ca avant d'effectuer un étalonnage automatique. Si vous laissez un signal d'entrée connecté au multimètre, il risque de perturber l'étalonnage.
- Les constantes d'étalonnage automatique sont enregistrées en mémoire permanente (qui ne s'efface pas à la mise hors tension de l'instrument). Vous n'êtes donc pas obligé d'effectuer un étalonnage automatique après chaque coupure d'alimentation (volontaire ou accidentelle).
- Les temps d'exécution de chaque routine d'étalonnage automatique sont les suivants:
 - ALL:11 minutes
 - DCV:1 minute
 - AC:1 minute
 - OHMS:10 minutes
- **Commandes connexes:** CAL, SCAL, SECURE

Exemple

OUTPUT 722;"ACAL ALL,3458A" !EXECUTION DE TOUS LES ETALONNAGES

ACBAND

AC band width. La commande ACBAND (bande passante ca) permet de spécifier la composante de fréquence (largeur de bande) du signal d'entrée pour les mesures de tension et de courant alternatifs ou alternatifs + continus. Spécifier la largeur de bande permet au multimètre de se configurer pour des mesures rapides.

Syntaxe

ACBAND [*fréquence_basse*][,*fréquence_haute*]

fréquence_basse Spécifie la fréquence la plus basse attendue du signal d'entrée.

fréquence_basse à la mise sous tension= 20 Hz

fréquence_basse par défaut= 20 Hz

fréquence_haute Spécifie la fréquence la plus haute attendue du signal d'entrée.

fréquence_haute à la mise sous tension= 20 MHz

fréquence_haute par défaut= 2 MHz

Points importants

- Se reporter aux spécifications de l'**annexe A** pour connaître la précision et la vitesse de lecture suivant la largeur de bande du signal d'entrée.
- Pour les mesures de tension alternative ou alternative + continue synchrones (commande SETACV SYNC), le multimètre utilise les paramètres de largeur de bande pour calculer les valeurs de temporisation et les paramètres d'échantillonnage. Si vous utilisez le déclenchement par niveau (mode par défaut) et que le signal d'entrée est retiré pendant une lecm.re et ne revient pas dans les limites de temps, la méthode de mesure passe automatiquement du mode synchrone au mode aléatoire pour que la lecture puisse se terminer. (Après la lecture la méthode de mesure revient à SYNC). Pour les mesures de tension alternative ou alternative + continue, il est très important que la largeur de bande spécifiée (notamment *fréquence_basse*) corresponde à la fréquence du signal mesuré.
- Si vous n'êtes pas sûr de la fréquence d'entrée, prenez les valeurs par défaut des paramètres ACBAND.

- **Commande d'interrogation:** La commande d'interrogation ACBAND? renvoie deux nombres séparés par une virgule. Le premier nombre est la *fréquence_basse* couramment spécifiée, le second nombre est la *fréquence_haute*. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** ACDCI, ACDCV, ACI, ACV, FREQ, FUNC, PER. SETACV

Exemple

```
OUTPUT 722;"ACBAND 500,1000" !SPECIFIE QUE LE: SIGNAL D'ENTREE EST  
!COMPRIS ENTRE 500 et 1000 Hz
```

ACDCI, ACDCV, ACI, ACV

Voir commande **FUNC**.

ADDRESS

La commande ADDRESS spécifie l'adresse GPIB (à partir du panneau avant uniquement). L'adresse est sauvegardée en mémoire permanente (elle n'est pas perdue à la mise hors tension de l'instrument).

Syntaxe

ADDRESS *valeur*

valeur Le paramètre *valeur* est un entier compris entre 0 et 31.

Valeur à la mise sous tension = adresse précédemment enregistrée (réglage usine= 22).

Valeur par défaut= sans; paramètre obligatoire.

Points importants

- L'adresse 31, lorsqu'elle est spécifiée, ne modifie pas l'adresse du multimètre mais le configure en mode Emetteur seulement. Dans ce mode, le multimètre envoie directement les lectures sur une imprimante GPIB sans contrôleur sur le bus (vous devez utiliser le format de sortie ASCII). L'indicateur **TALK** du multimètre s'allume lorsque l'instrument est en mode Emetteur seulement. Vous ne pouvez pas spécifier l'adresse 31 si un contrôleur est sur le bus. Pour sortir le multimètre du mode Emetteur seulement, appuyez sur la touche **Reset** ou spécifiez une adresse autre que 31.
- L'adresse du contrôleur est typiquement à 21. N'utilisez pas cette adresse pour un autre appareil configuré sur le bus GPIB.
- Lorsque le multimètre détecte une panne de RAM CMOS (bit d'erreur auxiliaire 12), il se configure à l'adresse 22.
- **Commande d'interrogation** ADDRESS?. Vous pouvez lire l'adresse courante à partir du panneau avant en appuyant sur la touche **Address** (touche [Shift]-(**Local**)).
- **Commandes connexes**: ID?

APER

Aperture. La commande APER permet de spécifier le temps d'intégration du convertisseur NN en secondes.

Syntaxe

APER [*ouverture*]

ouverture Spécifie le temps d'intégration du convertisseur NN et annule le temps d'intégration ou la résolution précédemment défini(e). La gamme du paramètre ouverture s'étend de 0 à 1 s par incréments de 100 ns. (Si vous spécifiez une valeur <500 ns, le temps d'ouverture minimal – 500 ns – est automatiquement sélectionné).

Ouverture à la mise sous tension = déterminée par la valeur de mise sous tension de NPLC qui spécifie un temps d'intégration de 166,667 ms pour une fréquence secteur de 60 Hz ou de 200 ms pour une fréquence secteur de 50 Hz ou de 400 Hz.

Ouverture par défaut = 500 ns

Points importants

- Comme les commandes APER et NPLC spécifient toutes deux le temps d'intégration, l'exécution de l'une de ces commandes annule automatiquement le temps d'intégration précédemment établi par l'autre. La commande RES ou le paramètre *%_résolution* d'une fonction ou de la commande RANGE peuvent également être utilisés pour sélectionner indirectement un temps d'intégration. Une interaction se produit alors avec la commande APER (ou NPLC) lorsque vous spécifiez la résolution que le multimètre résout comme suit:

Si vous envoyez la commande APER (ou NPLC) *avant* de spécifier la résolution, le multimètre satisfait la commande qui spécifie la plus grande résolution (plus grand temps d'intégration).

Si vous envoyez la commande APER (ou NPLC) *après* avoir spécifié la résolution, le multimètre utilise le temps d'intégration spécifié par la commande APER (ou NPLC) et ignore toute résolution spécifiée précédemment

- **Commande d'interrogation:** La commande d'interrogation APER? retourne le temps d'intégration couramment spécifié (en secondes) pour le convertisseur

A/N. Ce temps peut avoir été spécifié par une commande APER, NPLC ou RES ou par le paramètre *%_résolution* d'une commande de fonction ou de la commande RANGE. Pour plus de détails sur les **Commandes d'interrogation** se reporter au début du présent chapitre.

- **Commandes connexes:** FUNC, NPLC, RANGE, RES

Exemple

```
OUTPUT 722; "APER 10E-6" !SPECIFIE UNE OUVERTURE: DE 10
!MICROSECONDES
```

ARANGE

Autorange. La commande ARANGE (Gamme automatique) valide ou invalide la fonction de gamme automatique.

Syntaxe

```
ARANGE [contrôle]
```

contrôle Les valeurs possibles du paramètre contrôle sont:

Paramètre contrôle	Équivalent numérique	Description
OFF	0	Inactive l'algorithme de gamme automatique
ON	1	Active l'algorithme de gamme automatique
ONCE	2	Active l'algorithme pour une gamme automatique puis invalide la fonction de gamme automatique

Contrôle à la mise sous tension = ON.

Contrôle par défaut= ON.

Points importants

- Si la gamme automatique est validée, le 3458A échantillonne le signal d'entrée avant chaque mesure et sélectionne la gamme appropriée.
- Référez-vous à la commande **FUNC** ou **RANGE** pour une liste des gammes possibles pour chaque fonction de mesure.

- La gamme automatique ne fonctionne pas pour les mesures d'échantillons directs ou de sous-échantillons (commande DSAC, DSDC, SSAC ou SSDC) ou lorsque vous utilisez l'événement d'échantillonnage TIMER ou la commande SWEEP.
- **Commande d'interrogation:** La commande d'interrogation ARANGE? retourne une réponse indiquant le mode de gamme automatique courant. Pour plus de détails sur les **Commandes d'interrogation** se reporter au début du présent chapitre.
- **Commandes connexes:** FUNC, RANGE

Exemple

OUTPUT 722;"ARANGE OFF" !DISABLES AUTORANGE

AUXERR?

Auxiliary error. S'il détecte une erreur due au matériel, le 3458A positionne un bit dans le registre d'erreur auxiliaire. La commande AUXERR? (erreur auxiliaire) renvoie un nombre représentant ces bits positionnés et met le registre à zéro. Le nombre renvoyé est la somme pondérée de tous les bits positionnés.

Syntaxe

AUXERR?

Conditions d'erreur auxiliaire

Les conditions d'erreur auxiliaire et leurs valeurs pondérées sont:

Valeur pondérée	Bit numéro	Description
1	0	Le processeur esclave ne répond pas
2	1	Défaillance DTACK
4	2	Echec du test automatique du processeur esclave
8	3	Echec du test automatique d'isolation
16	4	Erreur de convergence du convertisseur A/N
32	5	Valeur d'étalonnage hors gamme

Valeur pondérée	Bit numéro	Description
64	6	Défaillance de la puce GPIB
128	7	Défaillance UART
256	8	Problème de chronomètre
512	9	Surcharge interne
1024	10	Erreur au total de contrôle de la ROM, octet de poids faible
2048	11	Erreur au total de contrôle de la ROM, octet de poids fort
4096	12	Défaillance de la RAM non-volatile
8192	13	Défaillance de la RAM en option
16384	14	Erreur de protection ou d'écriture de la RAM d'étalonnage

Points importants

- Le registre d'erreur auxiliaire indique des erreurs liées au matériel. Si un ou plusieurs bits sont positionnés, votre 3458A doit être réparé ou étalonné.
- La commande AUXERR? renvoie un zéro si aucun bit d'erreur n'est positionné.
- Si un bit du registre d'erreur auxiliaire est positionné, le 3458A positionne le bit O (erreur due au matériel) du registre d'erreur. La lecture du registre d'erreur auxiliaire n'efface pas le bit O du registre d'erreur. Pour effacer ce dernier, vous devez lire le registre d'erreur (commande ERR?).
- Vous ne pouvez pas masquer les bits du registre d'erreur auxiliaire pour les empêcher de positionner le bit O du registre d'erreur.
- **Commandes connexes:** EMASK, ERR?, ERRSTR?, TEST

Exemple

```

10 OUTPUT 722;"AUXERR?" !LIT LE REGISTRE D'ERREUR AUXILIAIRE
20 ENTER 722;A           !ENTRE LA SOMME PONDEREE DANS LA
                           !VARIABLE A
30 PRINT A               !IMPRIME LA SOMME PONDEREE
40 END

```

Par exemple, supposons que la commande AUXERR? renvoie la somme pondérée 3072. Cette valeur correspond aux erreurs. Total de contrôle de la ROM, octet de poids faible (1024) et total de contrôle de la ROM, octet de poids fort (2048).

AZERO

Autozero. La commande AZERO valide ou invalide la fonction d'auto-zéro (zéro automatique). Cette fonction ne s'applique qu'aux mesures de tension ou de courant continu(e) et aux mesures de résistance.

Syntaxe

AZERO [*contrôle*]

contrôle Les valeurs possibles du paramètre *contrôle* sont:

Paramètre <i>contrôle</i>	Équivalent numérique	Description
OFF	0	La mesure de zéro est réactualisée une fois, puis seulement après un changement de fonction, de gamme, d'ouverture, de périodes secteur (NPLC) ou de résolution.
ON	1	La mesure de zéro est réactualisée après chaque mesure.
ONCE	2	La mesure de zéro est réactualisée une fois, puis seulement après un changement de fonction, de gamme, d'ouverture, de périodes secteur (NPLC) ou de résolution.

Contrôle à la mise sous tension = ON

Contrôle par défaut = ON

Points importants

- Quand la fonction d'auto-zéro est ON (validée), le multimètre effectue une mesure de zéro (mesure avec entrée invalidée) après chaque lecture et soustrait la mesure de zéro de la lecture, ce qui double pratiquement le temps requis pour la mesure.
- Vous remarquerez que les paramètres contrôle OFF et ONCE ont le même effet. Lorsque la fonction d'auto-zéro est OFF ou ONCE, le multimètre effectue une seule mesure de zéro qu'il soustrait de toutes les mesures suivantes. Une fois la commande AZERO OFF ou AZERO ONCE exécutée, le multimètre effectue la mesure de zéro lorsque le premier événement d'armement de déclenchement se produit pour tous les événements sauf TARM EXT qui provoque une mesure de zéro lorsque la commande TARM EXT est exécutée.

La mesure de zéro sera ensuite réactualisée à chaque fois que la fonction de mesure, la gamme ou le temps d'intégration sera modifié (cette réactualisation s'opère lorsque l'événement d'armement de déclenchement se produit ou lorsque la commande TARM EXT est exécutée).

- L'indicateur d'affichage AZERO OFF s'allume lorsque le zéro automatique est invalidé.
- Le zéro automatique ne peut pas être invalidé pour les mesures de courant continu.
- Pour les mesures de résistance 2-fils avec compensation de décalage, la mesure de zéro et la mesure du décalage sont effectuées simultanément.
- Il est conseillé de valider la fonction de zéro automatique pour les mesures de résistance 4-fils. Si pour une raison quelconque, vous devez invalider cette fonction, assurez-vous que toutes les connexions de mesure sont établies avant d'invalider le zéro automatique et que la résistance des cordons de mesure ne changera pas. Si vous invalidez le zéro automatique avant d'effectuer les connexions 4-fils ou si la résistance des cordons de mesure varie alors que la fonction est invalidée (comme c'est le cas lors d'une scrutation), vos mesures de résistance 4-fils seront imprécises.
- **Commande d'interrogation:** La commande d'interrogation AZERO?
- retourne le mode courant du zéro automatique. Pour plus de détails sur les **Commandes d'interrogation** se reporter au début du présent chapitre.
- **Commandes connexes:** DCI, DCV, FUNC, OHM, OHMF

Exemple

```
OUTPUT 722; "AZERO OFF" !INVALIDE LE ZERO AUTOMATIQUE
```

BEEP

La commande BEEP contrôle l'indicateur sonore du 3458A. S'il est validé, cet indicateur signale les situations d'erreur par une tonalité de 1 kHz.

Syntaxe

BEEP [*contrôle*]

contrôle Les valeurs possibles du paramètre *contrôle* sont:

Paramétré contrôle	Équivalent numérique	Description
OFF	0	Invalide l'indicateur sonore.
ON	1	Valide l'indicateur sonore.
ONCE	2	Retentit une fois puis retourne au mode précédent (validé ou invalidé).

Contrôle à la mise sous tension = dernière valeur programmée.
Contrôle par défaut= ONCE.

Points importants

- Le 3458A enregistre la valeur de contrôle en mémoire non-volatile (la valeur n'est pas perdue à l'arrêt de l'instrument).
- **Commande d'interrogation**: La commande d'interrogation BEEP? retourne le mode courant de l'indicateur sonore. Pour plus de détails sur les **Commandes d'interrogation** se reporter au début du présent chapitre.
- **Commandes connexes**: TONE

Exemple

`OUTPUT 722;"BEEP OFF" !INVALIDE L'INDICATEUR SONORE`

CAL

Cette commande est une commande d'étalonnage. Pour plus de détails à son sujet, référez-vous au manuel d'étalonnage du 3458A.

CALL

Call subprogram. La commande CALL exécute un sous-programme précédemment enregistré.

Syntaxe

`CALL [nom]`

nom Nom du sous-programme. Celui-ci peut comporter jusqu'à 10 caractères. Le nom peut être alphabétique, alphanumérique ou un entier compris entre 0 et 127. Pour plus de détails à ce sujet, voir également commande **SUB** dans ce chapitre.

Nom à la mise sous tension= aucun

Nom par défaut= 0

Points importants

- Les sous-programmes sont créés avec la commande SUB.
- Le multimètre positionne le bit 0 du registre d'état après avoir exécuté un sous-programme enregistré.
- Vous pouvez visualiser le nom de tous les sous-programmes enregistrés à partir du panneau avant en accédant à la commande CALL et en appuyant sur les touches fléchées (vers le haut ou vers le bas) pour faire défiler la liste des noms sur l'affichage. Une fois le sous-programme recherché affiché, appuyez sur la touche **Enter** pour l'exécuter.
- **Commandes connexes:** COMPRESS, CONT, DELSUB, PAUSE, SCRATCH, SUB, SUBEND

Exemples

```
OUTPUT 722;"CALL DCCUR2" !EXECUTE LE SOUS-PROGRAMME 1 APPELE
! "DCCUR2"
```

CALNUM?

Calibration number query. La commande d'interrogation CALNUM? renvoie un entier indiquant le nombre d'étalonnages effectués sur votre 3458A.

Syntaxe

CALNUM?

Points importants

- Le nombre d'étalonnage est incrémenté de 1 à chaque fois que le multimètre est étalonné. Si l'étalonnage automatique est protégé par un code de sécurité, le nombre d'étalonnages est également incrémenté de 1 à chaque étalonnage automatique. S'il n'est pas protégé par un code de sécurité, l'étalonnage

- automatique n'affecte pas le nombre d'étalonnages.
- Votre 3458A a été étalonné avant le départ d'usine. Quand vous le recevez, lisez le nombre d'étalonnages pour déterminer sa valeur initiale.
- Le nombre d'étalonnages est enregistré en mémoire non-volatile (il n'est pas perdu quand l'appareil est mis hors tension).
- **Commandes connexes:** CAL, CALSTR, SCAL

Exemple

```
10 OUTPUT 722;"CALNUM?" !LIT LE NOMBRE D'ETALONNAGES
20 ENTER 722;A          !ENTRE LA REPONSE DANS LA VARIABLE A
30 PRINT A              !IMPRIME LA REPONSE
40 END
```

CALSTR

Calibration string (remote only). La commande CALSTR (programmation à distance uniquement) enregistre une chaîne dans la RAM d'étalonnage non-volatile du multimètre. Cette chaîne est typiquement utilisée pour sauvegarder la température interne du multimètre au moment de l'étalonnage (commande **TEMP?**), la date d'étalonnage, le nom du technicien et la date prévue pour le prochain étalonnage.

Syntaxe

CALSTR *chaîne*[*code_sécurité*]

chaîne C'est un message alphanumérique qui sera ajouté dans la RAM d'étalonnage. Le paramètre chaîne doit être saisi entre guillemets ou apostrophes. Il peut comporter jusqu'à 75 caractères (les guillemets délimitant la chaîne ne comptent pas pour des caractères).

code_sécurité Si la RAM d'étalonnage est protégée (commande **SECURE**), vous devez saisir le code de sécurité pour pouvoir écrire un message dans la RAM d'étalonnage. (Par contre, vous pouvez lire directement la chaîne à l'aide de la commande CALSTR? que la RAM soit protégée ou non). Pour plus de détails sur la procédure de validation/invalidation du code de sécurité de la RAM d'étalonnage, se reporter à la commande **SECURE**.

Points importants

- **Commande d'interrogation:** La commande d'interrogation CALSTR? retourne la chaîne de caractères de la RAM d'étalonnage du multimètre comme l'illustre le second exemple ci-dessous.
- **Commandes connexes:** CAL, CALNUM?, SCAL, SECURE

Exemples

CALSTR

OUTPUT 722;"CALSTR 'ETALONNE LE 04/02/1987'"

CALSTR?

```
10 DIM A$[80]           !DIMENSIONNE LA VARIABLE ALPHANUMERIQUE
20 OUTPUT 722; "CALSTR?" !LIT LA CHAINE
30 ENTER 722;A$          !ENTRE LA CHAINE
40 PRINT A$              !IMPRIME LA CHAINE
50 END
```

COMPRESS

Compress subprogram. La commande CO:MPRESS extrait le texte ASCII d'un sous-programme spécifié, précédemment enregistré en mémoire. Ceci permet de gagner de l'espace mémoire mais enlève le sous-programme de la mémoire permanente (le sous-programme sera effacé à la mise hors tension de l'instrument).

Syntaxe

COMPRESS *nom*

nom Nom du sous-programme. Celui-ci peut comporter jusqu'à 10 caractères. Le nom peut être alphabétique, alphanumérique ou un entier compris entre 0 et 127. Pour plus de détails à ce sujet, voir également commande **SUB** dans ce chapitre.

Nom à la mise sous tension= aucun

Nom par défaut = aucun; paramètre obligatoire

Points importants

- Pour éviter de fragmenter la mémoire, compressez chaque sous-programme avant d'en télécharger d'autres.
- Vous ne pouvez pas enregistrer la commande COMPRESS comme commande figurant dans un sous-programme.
- **Commandes connexes:** CALL, CONT, DELSUB, PAUSE, SCRATCH, SUB, SUBEND

Exemple

L'instruction suivante compresse le sous-programme TEST12 (préalablement téléchargé depuis un ordinateur distant).

```
OUTPUT 722;"COMPRESS TEST12"
```

CONT

Continue. La commande CONT poursuit l'exécution d'un sous-programme précédemment suspendue par une commande PAUSE.

Syntaxe

CONT

Points importants

- La commande GPIB GET (Déclenchement d'un groupe d'appareils) peut également être utilisée pour poursuivre l'exécution d'un sous-programme suspendu.
- Un seul sous-programme peut être suspendu à la fois. Si un sous-programme est suspendu alors qu'un autre s'exécute et est suspendu à son tour, le premier terminera de s'exécuter alors que le second restera suspendu.
- **Commandes connexes:** PAUSE, SUB, SUBEND

Exemple

```
OUTPUT 722;"CONT" !POURSUITE DE L'EXECUTION DU SOUS
                  !PROGRAMME
```

CSB

Clear status byte. La commande CSB (Mise à zéro de l'octet d'état) efface (met à zéro) tous les bits du registre d'état.

Syntaxe

CSB

Points importants

- Si un événement qui a positionné un bit dans le registre d'état est toujours valide; le bit sera remis à immédiatement après l'envoi de la commande CSB.
- Quand vous effacez le bit 6 (demande de service), le 3458A force la ligne SRQ de l'interface GPIB au niveau faux.
- **Commandes connexes:** RQS, SPOLL (commande GPIB), STB?

Exemple

```
OUTPUT 722;"CSB" !EFFACE LE REGISTRE D'ETAT
```

DCI, DCV

Voir commande **FUNC**.

DEFEAT

La commande DEFEAT valide ou invalide l'algorithme de protection des entrées du multimètre (voir ATTENTION ci-dessous) et certains algorithmes de vérification de syntaxe et d'erreur. Lorsque ces algorithmes sont invalidés, le multimètre change de configuration de mesure plus rapidement.

Syntaxe

```
DEFEAT [mode]
```

mode Les choix possibles pour le paramètre mode sont les suivants:

Paramètre <i>mode</i>	Équivalent numérique	Description
OFF	0	Valide les algorithmes de protection des entrées, de vérification de syntaxe et d'erreur
ON	1	Invalide les algorithmes de protection des entrées, de vérification de syntaxe et d'erreur

Mode à la mise sous tension = OFF

Mode par défaut= OFF

Points importants

ATTENTION

La fonction DEFEAT ON ne doit être utilisée que lorsque vous êtes certain que les tension de surcharge sur les bornes Input (Entrée) n'excéderont pas ± 100 V crête dans la gamme 10 V ou une gamme inférieure. (Sur les gammes 100 V et 1000 V, le multimètre acceptera des tensions jusqu'à ± 1200 V crête, que la fonction DEFEAT soit ON ou OFF). DEFEAT ON invalide (élimine) la séquence qui protège les circuits d'entrée du multimètre contre les surtensions. Si une condition de surcharge est détectée sur la gamme JO V ou une gamme inférieure alors que la protection des circuits d'entrée est invalidée, le multimètre revalidera la protection des entrées et contrôlera de manière interne la surcharge interdite pour des raisons de garantie de l'instrument.

- Dans la mesure où DEFEAT ON invalide certains algorithmes de vérification de syntaxe et d'erreur, il est conseillé de ne l'utiliser que lorsque la programmation du système est terminée et opérationnelle.
- **Commande d'interrogation:** La commande d'interrogation DEFEAT? retourne le mode DEFEAT courant. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.

Exemple

```
OUTPUT 722;"DEFEAT ON" !INVALIDE LES ALGORITHMES DE PROTECTION
!DES ENTREES ET CERTAINS ALGORITHMES DE
!VERIFICATION CE SYNTAXE ET D'ERREUR
```

DEFKEY

Define key. La commande DEFKEY vous permet d'affecter une ou plusieurs commandes à une touche de fonction définissable par l'utilisateur (touches **f0** à **f9** du panneau avant). Après avoir affecté une ou plusieurs commandes à une touche, il suffit d'appuyer sur cette touche pour afficher la ou les commande(s) lui correspondant sur l'affichage du multimètre. Appuyez ensuite sur **Enter** pour exécuter la (ou les) commande(s) dans l'ordre où elles sont affichées. La commande DEFKEY DEFAULT efface les chaînes affectées à toutes les touches définies par l'utilisateur.

Syntaxe

DEFKEY *nombre,chaîne*

ou

DEFKEY DEFAULT

nombre Le paramètre nombre est un entier compris entre 0 et 9 qui identifie une touche de fonction particulière (f0 à f9).

Nombre à la mise sous tension= aucun

Nombre par défaut= 0

chaîne Le paramètre chaîne correspond à la commande (ou aux commandes) à affecter à une touche de fonction. (Les commandes multiples doivent être séparées par des points-virgules). Le paramètre chaîne doit figurer entre guillemets (ou apostrophes). La chaîne peut comporter un maximum de 40 caractères (les guillemets délimitant la chaîne ne comptent pas pour des caractères).

chaîne à la mise sous tension = aucune

chaîne par défaut = aucune (efface toute chaîne précédemment définie)

DEFAULT

Efface les chaînes affectées à toutes les touches définies par l'utilisateur.

Points importants

- Les définitions de touches sauvegardées à partir du panneau avant peuvent être modifiées à partir du panneau avant. Les définitions sauvegardées depuis un ordinateur distant ne peuvent pas être modifiées.
- Vous ne pouvez pas délimiter une chaîne DEFKEY (entre guillemets) par d'autres guillemets. Ce qui signifie que vous ne pouvez pas utiliser la commande DISP avec un message entre guillemets comme paramètre chaîne. Vous pouvez toutefois utiliser la commande DISP suivie d'un message sans guillemets. (Voir commande **DISP** pour les restrictions s'appliquant aux messages non délimités par des guillemets).
- **Commande d'interrogation:** La commande d'interrogation DEFKEY? retourne le paramètre chaîne couramment affecté à une touche de fonction en particulier (voir exemple ci-dessous). La chaîne renvoyée par la commande DEFKEY? est entre guillemets, que vous ayez utilisé des guillemets ou des apostrophes (simples) pour la spécifier.

- **Commandes connexes:** LOCK, MENU

Exemples

DEFKEY

```
OUTPUT 722;"DEFKEY 1,'DCI 1;AZERO 0FF;NPLC 0'"!AFFECTATION DE PLUSIEURS
!COMMANDES A LA TOUCHE F1
```

Effacement de toutes les définitions

```
OUTPUT 722;"DEFKEY DEFAULT" !EFFACE TOUTES LES TOUCHES DEFINIES
!PAR L'UTILISATEUR
```

DEFKEY?

```
10 OUTPUT 722;"DEFKEY? 1" !RETOURNE LA DEFINITION DE LA TOUCHE 1
20 ENTER 722;A$           !ENTRE LA DEFINITION DANS LA VARIABLE A$
30 PRINT A$               !IMPRIME LA DEFINITION
40 END
```

Une réponse typique retournée par le programme ci-dessus sera: "DCI 1;AZERO OFF;NPLC 0." Si aucune commande n'avait été affectée à la touche F1, le programme ci-dessus retourne: "DEFKEY F1."

DELAY

La commande DELAY (Retard) vous permet de spécifier un intervalle de temps qui sera inséré entre l'événement de déclenchement et le premier événement d'échantillonnage. (La commande DELAY peut également être utilisée pour insérer un retard entre chaque événement Source de synchronisation et le premier échantillon de chaque groupe d'échantillons lorsque vous procédez à un sous-échantillonnage (numérisation)).

Syntaxe

DELAY [*valeur de retard*]

valeur de retard Spécifie le retard en secondes. Le retard spécifié peut varier de 1E-7 (100 ns) à 6000 secondes par incréments de 100 ns. La valeur 0 spécifie le retard à sa plus petite valeur possible.

Valeur de retard à la mise sous tension = automatique (déterminée par la fonction, la gamme, la résolution et la sélection de ACBAND).

Valeur de retard par défaut = automatique (déterminée par la fonction, la gamme, la résolution et la sélection de ACBAND).

Points importants

- Le retard par défaut change automatiquement (à moins que vous n'ayez spécifié une valeur de remplacement) à chaque fois que vous changez la fonction de mesure (DCV, ACV, etc.), la gamme, la résolution ou la largeur de bande ca (commande ACBAND).
- **Commande d'interrogation**: La commande d'interrogation DELAY? retourne la valeur de retard courante (en secondes). Pour plus de détails sur les **Commandes d'interrogation** se reporter au début du présent chapitre.
- **Commandes connexes**: NRDGS, SWEEP, TIMER, TRIG

Exemples

OUTPUT 722;"DELAY 5" !INSERE UN RETARD DE 5 SECONDES

OUTPUT 722;"DELAY -1" !RETOURNE A LA VALEUR DE RETARD PAR
!DEFAULT (AUTOMATIQUE)

DELSUB

Delete subprogram. La commande DELSUB supprime le sous-programme spécifié de la mémoire.

Syntaxe

DELSUB *nom*

nom Nom du sous-programme. Celui-ci peut comporter jusqu'à 10 caractères. Le nom peut être alphabétique, alphanumérique ou un entier compris entre 0 et 127. Pour plus de détails à ce sujet, voir également commande **SUB** dans ce chapitre.

Nom à la mise sous tension= aucun

Nom par défaut= aucun; paramètre obligatoire

Points importants

- Lorsqu'un sous-programme est supprimé, l'espace mémoire qu'il occupait est libéré et peut être utilisé pour enregistrer un nouveau sous-programme (voir commande **SUB**).
- Pour supprimer simultanément tous les sous-programmes en mémoire, utilisez la commande SCRATCH.
- **Commandes connexes:** COMPRESS, SCRATCH, SUB

Exemple

```
OUTPUT 722;"DELSUB TEST12" !SUPPRIME LE SOUS-PROGRAMME TEST12
```

DIAGNOST

Cette commande est une commande de maintenance. Pour plus de détails à son sujet, se reporter au manuel de maintenance du 3458A.

DISP

Display. La commande DISP valide ou invalide l'affichage du multimètre et peut également être utilisée pour afficher un message ou effacer l'affichage.

Syntaxe

DISP [*contrôle*] [,*message*]

contrôle Les valeurs possibles du paramètre *contrôle* sont:

Paramètre <i>contrôle</i>	Équivalent numérique	Description
OFF	0	Affiche l'éventuel message (s'il n'y a pas de message, des tirets s'affichent); invalide tous les indicateurs lumineux, à l'exception de ERR; les lectures ne s'affichent plus et l'affichage n'est pas réactualisé sauf pour répondre à une touche du panneau avant ou aux commandes d'interrogation.
ON	1	Fonctionnement normal de l' affichage (mode de mise sous tension).
MSG	2	Affiche le message, indicateurs lumineux actifs.
CLR	3	Efface l'affichage.

Contrôle à la mise sous tension = ON

Contrôle par défaut = ON

message Le paramètre *message* est le message à afficher. Il peut renfermer des espaces, des chiffres, des lettres minuscules ou majuscules et les caractères suivants:

! # \$ % & ' () ^ \ / @ ; : [] , . + - = * < > ? _

Points importants

- Vous ne devez placer le message entre guillemets que s'il renferme un espace, une virgule ou un point-virgule. L'apostrophe simple (') ou le guillemet (") peut être utilisé mais les délimiteurs de début et de fin doivent correspondre (être identiques).
- Un message peut comporter jusqu'à 75 caractères (les guillemets délimitant le message ne comptent pas pour des caractères).
- **Commande d'interrogation:** La commande d'interrogation DISP? renvoie le paramètre contrôle couramment spécifié. Pour plus de détails sur les **Commandes d'interrogation** se reporter au début du présent chapitre.
- **Commandes connexes:** NDIG

Exemples

La commande suivante force le multimètre à afficher le message TIME-OUT et à interrompre automatiquement la mise à jour de l'affichage.

```
OUTPUT 722;"DISP OFF,TIME-OUT" !AFFICHE TIME-OUT
```

Dans la commande suivante, le message est placé entre guillemets car il contient un espace.

```
OUTPUT 722;"DISP MSG,'TIME OUT'" !AFFICHE TIME OUT
```

DSAC, DSDC

Direct-sampling. Ces commandes configurent le multimètre pour des mesures d'échantillons directs (numérisation). La fonction DSAC ne mesure que la composante alternative du signal d'entrée. La fonction DSDC mesure les composantes alternative et continue combinées. A ce détail près, les deux fonctions sont identiques. Elles utilisent toutes deux l'échantillonneur-bloquer (ouverture de 2 nanosecondes) et une largeur de bande de 12 MHz.

Syntaxe

```
DSAC [entrée_max] [,%_resolution]
```

```
DSDC [entrée_max] [,%_resolution]
```

entrée_max Sélectionne la gamme de la mesure. (Le changement de gamme automatique n'est pas autorisé en mode sous-échantillonnage). Pour sélectionner une gamme, vous spécifiez **entrée_max** comme étant l'amplitude crête attendue du signal d'entrée. Le multimètre choisit alors la gamme lui correspondant Le tableau ci-dessous montre les paramètres **entrée_max** et les gammes qu'ils sélectionnent.

Paramètre entrée_max	Sélectionne la gamme	Plaine échelle	
		Format SINT	Format DINT
0 à 0,012	10 mV	12 mV	50 mV
>0,012 à 0,120	100 mV	120 mV	500 mV
>0,120 à 1,2	1 V	1,2 V	5,0 V
>1,2 à 12	10 V	12 V	50 V
>12 à 120	100 V	120 V	500 V
>120 à 1E3	1000 V	1050 V	1050 V

Entrée_max à la mise sous tension= non applicable
Entrée_max par défaut= 10 V

%_resolution Ce paramètre est ignoré par le multimètre lorsqu'il est utilisé avec la commande DSAC ou DSDC. Il ne figure dans la syntaxe de la commande que pour des raisons de cohérence avec les autres fonctions de mesure (FUNC, ACT, DCV, etc.).

Points importants

- En mode Échantillonnage direct, vous ne pouvez pas utiliser la fonction de changement de gamme automatique; vous devez spécifier la gamme comme premier paramètre de la commande DSAC ou DSDC (paramètre *Entrée_max*).
- Lorsque vous utilisez le format de mémoire/sortie DINT, les valeurs de pleine échelle en échantillonnage direct correspondent à 500% (5 fois) des gammes de 10 mV, 100 mV, 1V, 10V et 100V. C'est un point très important dont il faut tenir compte pour spécifier le pourcentage auquel se produira le déclenchement Supposons par exemple que le signal d'entrée ait une valeur crête de 20V et que vous utilisiez la gamme 1 0V. Si vous désirez un

déclenchement à 15V, spécifiez un pourcentage de déclenchement de 150% (commande LEVEL 150). (Le front de montée des amplificateurs du multimètre peut être dépassé lorsque vous mesurez un signal dont la fréquence est > 2 MHz et l'amplitude $> 120\%$ de la gamme. Les signaux $\leq 120\%$ de la gamme avec des fréquences jusqu'à 12 MHz ne génèrent pas d'erreur du Front de montée).

- La hiérarchie de déclenchement du multimètre (événement d'armement, de déclenchement et d'échantillonnage) s'applique à l'échantillonnage direct c'est-à-dire que ces événements doivent se produire dans le bon ordre avant que l'échantillonnage direct ne commence. Pour plus de détails sur cette hiérarchie, se reporter au **chapitre 4**. En mode Échantillonnage direct, vous pouvez utiliser soit l'événement d'échantillonnage TIMER et la commande NRDGS n. TIMER soit la commande SWEEP (SWEEP est plus simple à programmer). Les commandes NRDGS et SWEEP sont interchangeables et le multimètre utilise celle des deux qui a été spécifiée en dernier. (Avec la commande SWEEP, l'événement d'échantillonnage est automatiquement défini à TIMER).
- Pour l'échantillonnage direct, il est conseillé d'utiliser le format de mémoire/sortie SINT lorsque la valeur crête du signal d'entrée est $< 120\%$ de la gamme spécifiée. Utilisez le format de mémoire/sortie DINT lorsque le signal d'entrée est $\geq 120\%$ de la gamme. (SINT et DINT sont les formats utilisés de manière interne par le convertisseur A/N; si vous choisissez correctement le format de mémoire/sortie, aucune conversion de format ne sera requise).
- **Commandes connexes:** DSDC, FUNC, LEVEL, LFILTER, SLOPE, NRDGS, PRESET FAST, PRESET DIG, SSAC, SSDC, SSPARM?, SWEEP, TARM, TIMER, TRIG

Exemple

Le programme suivant donne un exemple de numérisation par échantillonnage direct, à couplage CC. La commande SWEEP spécifie un intervalle de 30 μ s et 200 échantillons. Le niveau de déclenchement est défini à 250% de la gamme 10 V (250% de 10V = 25V). Les échantillons sont enregistrés en mémoire de lecture au format DINT. Les échantillons sont ensuite transmis au contrôleur, convertis et imprimés. Si vous supprimez la ligne 110, les échantillons seront directement transmis au contrôleur sans passer par la mémoire de lecture. Le contrôleur et le bus doivent toutefois pouvoir transférer des échantillons à la vitesse d'au moins 134 Ko/seconde, sinon le multimètre générera l'erreur TRIGGER TOO FAST

(Déclenchement trop rapide). Pour plus de détails à ce sujet, voir [Transfert à grande vitesse par le bus GPIB](#) au [chapitre 4](#).

```

10 OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Num_samples,I,J,K    ! CREE LES VARIABLES ENTIERES
30 Num_samples = 200            ! 200 ECHANTILLONS
40 ASSIGN @Dvm TO 722           ! AFFECTATION DE L'ADRESSE DU MULTIMETRE
50 ASSIGN @Buffer TO BUFFER [4*Num_samples] ! CONFIGURE LA
52 ! MEMOIRE-TAMPON DU CONTROLEUR POUR LES ECHANTILLONS (4
55 ! OCTETS/ECHANTILLON * 200 ECHANTILLONS = 800 OCTETS)
60 ALLOCATE REAL Samp(1:Num_samples) ! CREE LE TABLEAU DES REELS
65 ! POUR LES ECHANTILLONS
70 OUTPUT @Dvm;"PRESET FAST"    ! FORMATS DINT, TARM SYN, TRIG AUTO
80 OUTPUT @Dvm;"SWEEP 30E-6,200" ! INTERVALLE 30 µs, 200
85                                ! ECHANTILLONS
90 OUTPUT @Dvm;"DSDC 10"        ! ECHANTILLONNAGE DIRECT, GAMME 10 V
100 OUTPUT @Dvm;"LEVEL 250, DC" ! DECLenchement A 250% DE LA GAMME(25V)
110 OUTPUT @Dvm;"TRIG LEVEL"    ! EVENEMENT DE DECLenchement PAR NIVEAU
120 OUTPUT @Dvm;"MEM FIFO"      ! VALIDE LA MEMOIRE DE LECTURE, MODE FIFO
130 TRANSFER @Dvm TO @Buffer;WAIT ! TRANSMET LES ECHANTILLONS AU
135                                ! CONTROLEUR
140 OUTPUT @Dvm;"ISCALE?"       ! INTERROGATION DU FACTEUR D'ECHELLE POUR
145                                ! LE FORMAT DINT
150 ENTER @Dvm;S                ! ENTRE LE FACTEUR D'ECHELLE
160 FOR I=1 TO Num_samples
170 ENTER @Buffer USING "#,W,W";J,K ! ENTRE UN MOT DE 16 BITS
172 ! NOTATION COMPLEMENT A 2 ·DANS CHAQUE VARIABLE J ET K (#=
175 ! FIN D'INSTRUCTION NON REQUISE; W = ENTRER DONNEES SOUS
177 ! FORME D'ENTIERES 16 BITS NOTATION COMPLEMENT A 2)
180 Samp(I)=(J*65536.+K+65536.*(K<0)) ! CONVERSION EN NOMBRE REEL
190 R=ABS(Samp(I))                ! UTILISATION DE LA VALEUR ABSOLUE POUR
195                                ! VERIFIER SURCHARGE
200 IF R>2147483647 THEN PRINT "OVLD" ! SI SURCHARGE, IMPRESSION
205                                ! D'UN MESSAGE
210 Samp(I)=Samp(I)*S            ! APPLICATION DU FACTEUR D'ECHELLE
220 Samp(I)=DROUND(Samp(I),8)    ! ARRONDIT LES LECTURES CONVERTIES
230 PRINT Samp(I)                ! IMPRESSION DES LECTURES

```


240 NEXT I
250 END

EMASK

Error mask. La commande EMASK (masque d'erreur) vous permet de désigner quelles conditions d'erreur positionneront le bit d'erreur (bit 5) dans le registre d'état.

Syntaxe

EMASK [*valeur*]

valeur Vous validez (désignez) mie condition d'erreur en spécifiant sa valeur pondérée décimale comme paramètre *valeur*. Pour plusieurs conditions d'erreur, spécifiez la somme des valeurs pondérées. Les conditions d'erreur et leurs valeurs pondérées sont:

Valeur pondérée	Bit numéro	Valide la condition d'erreur
1	0	Erreur de matériel (pour plus de détails, voir AUXERR?)
2	1	Erreur d'étalonnage
4	2	Déclenchement trop rapide
8	3	Erreur de syntaxe
16	4	Commande non autorisée à distance (commande ADDRESS)
32	5	Paramètre reçu non défini
64	6	Paramètre hors gamme
128	7	Erreur de mémoire
256	8	Détection d'une surcharge destructrice
512	9	Hors étalonnage
1024	10	Étalonnage requis
2048	11	Conflit de configuration (mémoire mal configurée pour un sous-échantillonnage)

Valeur pondérée	Bit numéro	Valide la condition d'erreur
4096	12	Erreur mathématique (division par 0, dépassement d'entier, etc.)
8192	13	Erreur de sous-programme (appel d'un sous-programme précédemment supprimé, CONT sans PAUSE, SUBENC et PAUSE seulement autorisés dans SUB; SCRATCH, DELSUB, CONT, non autorisés dans SUB)
16384	14	Erreur système

Valeur à la mise sous tension= 32767 (tous validés)

Valeur par défaut= 32767 (tous validés)

Points importants

- Quand mie erreur se produit, elle positionne le bit lui correspondant dans le registre d'erreur, qu'il ait été ou non validé par la commande EMASK. L'invalidation d'un bit d'erreur l'empêche de positionner le bit d'erreur du registre d'état seulement et donc de générer mie demande de service.
- **Commande d'interrogation:** La commande d'interrogation EMASK? retourne la somme pondérée de toutes les conditions d'erreur validées (voir exemple ci-dessous).
- **Commandes connexes:** AUXERR?, ERR?, ERRSTR?, RQS, STB?

Exemples

```

OUTPUT 722;"EMASK 4"           ! VALIDE L'ERREUR DE DECLenchement TROP
                                ! RAPIDE
OUTPUT 722;"EMASK 248"         ! VALIDE LES CONDITIONS O'ER.'OEUR 8, 16,
                                ! 32, 64 ET 128
OUTPUT 722;"EMASK 0"           ! INVALIDE TOUTES LES ERREURS
10 OUTPUT 722; "EMASK?"         ! RETOURNE LA VALEUR EMASK
20 ENTER 722;A                  ! ENTRE LA REponse
30 PRINT A                      ! IMPRIME LA VALEUR
40 END

```

END

La commande END valide ou invalide la fonction GPIB EOI (End Or Identify Fin ou Identifier).

Syntaxe

END [*contrôle*]

contrôle Les valeurs possibles du paramètre *contrôle* sont:

Paramètre <i>contrôle</i>	Équivalent numérique	Description
OFF	0	La ligne EOI n'est jamais mise vraie
ON	1	En cas de lectures multiples (SWEEP ou NRDGS > 1), la ligne EOI est mise vraie avec le dernier octet de la dernière lecture envoyée. En cas de lecture unique, la ligne EOI est mise vraie avec le dernier octet de donnée.
ALWAYS	2	La ligne EOI est mise vraie avec le dernier octet de donnée.

Contrôle à la mise sous tension = OFF

Contrôle par défaut = ALWAYS.

Points importants

- Le format de sortie ASCII envoie *cr,if* (retour chariot-saut de ligne) sur le bus de données après chaque transmission de données. Cela indique la fin de la transmission pour la plupart des ordinateurs. Les autres formats de sortie n'envoient pas la séquence *cr if*. Lorsque vous rappelez plusieurs lectures de la mémoire avec le format de sortie ASCII à l'aide de la commande RMEM, le multimètre place une virgule entre les lectures. Dans ce cas, la séquence *cr,if* n'est envoyée qu'une seule fois, avec la dernière lecture du groupe rappelé. Les virgules ne sont pas utilisées lorsque les lectures sont directement envoyées sur le bus (mémoire de lecture invalidée), lorsque le rappel utilise la méthode de "lecture implicite" ou lorsqu'un autre format de sortie est utilisé.
- Reportez-vous au manuel de votre ordinateur pour voir comment celui-ci répond à la ligne EOI.

- Si END ALWAYS est spécifié en mode grande vitesse, la ligne EOI passe automatiquement à ON pendant les lectures. Une fois les lectures terminées, la ligne EOI revient à AL WAYS. Pour plus de détails sur le mode grande vitesse, se reporter au [chapitre 4](#), paragraphe [Augmentation de la vitesse de lecture](#).
- **Commande d'interrogation:** La commande d'interrogation END? retourne le mode EOI courant Pour plus de détails sur les [Commandes d'interrogation](#), se reporter au début du présent chapitre.
- **Commandes connexes:** OFORMAT

Exemple

```
OUTPUT 722;"END ALWAYS" !VALIDE LA LIGNE EOI OU GPIB
```

ERR?

Error query. Quand une erreur se produit, elle positionne un bit dans le registre d'erreur et fait clignoter l'indicateur ERR de l'affichage. La commande ERR? (erreur?) renvoie un nombre représentant tous les bits positionnés, initialise le registre, et éteint l'indicateur. Le nombre renvoyé est la somme pondérée de tous les bits positionnés.

Syntaxe

ERR?

Conditions d'erreur

Les conditions d'erreur et leurs valeurs pondérées sont:

Valeur pondérée	Bit numéro	Valide la condition d'erreur
1	0	Erreur de matériel (pour plus de détails, voir AUXERR?)
2	1	Erreur d'étalonnage
4	2	Déclenchement trop rapide
8	3	Erreur de syntaxe
16	4	Commande non autorisée à distance (commande ADDRESS)

Valeur pondérée	Bit numéro	Valide la condition d'erreur
32	5	Paramètre reçu non défini
64	6	Paramètre hors gamme
128	7	Erreur de mémoire
256	8	Détection d'une surcharge destructrice
512	9	Hors étalonnage
1024	10	Étalonnage requis
2048	11	Conflit de configuration (mémoire mal configurée pour un sous-échantillonnage)
4096	12	Erreur mathématique (division par 0, dépassement d'entier, etc.)
8192	13	Erreur de sous-programme (appel d'un sous-programme précédemment supprimé, CONT sans PAUSE, SUBEND et PAUSE seulement autorisés dans SUB; SCRATCH, DELSUB, CONT, non autorisés dans SUB)
16384	14	Erreur système

Points importants

- La commande ERR? retourne un 0 si aucun bit d'erreur n'est positionné.
- Si le bit 0 est positionné (valeur pondérée 1), référez-vous au registre d'erreur auxiliaire (commande **AUXERR?**) pour plus d'informations.
- L'exécution de la commande ERR? met à zéro le bit d'erreur du registre d'état (bit 5).
- **Commandes connexes:** AUXERR?, EMASK, ERRSTR?

Exemple

```

10 OUTPUT 722;"ERR?" !LIT & INITIALISE LE REGISTRE C'ERREUR
20 ENTER 722;A       !ENTRE LA SOMME PONDEREE DANS LA
25                   !VARIABLE A
30 PRINT A           !IMPRIME LA SOMME PONDEREE
40 END

```

ERRSTR?

Error string query. La commande d'interrogation ERRSTR? lit le bit le moins significatif positionné dans le registre d'erreur ou le registre d'erreur auxiliaire puis le remet à 0. La commande ERRSTR? renvoie deux réponses, séparées par une virgule. La première réponse correspond au numéro de l'erreur (préfixe 100 = registre d'erreur; préfixe 200 = registre d'erreur auxiliaire); la deuxième réponse est un message (chaîne) expliquant l'erreur.

Syntaxe

ERRSTR?

Points importants

- La chaîne retournée par la commande ERRSTR? comporte 255 caractères maximum.
- La commande ERRSTR? ne lit et ne remet à 0 que le bit le moins significatif positionné dans un registre. Si plusieurs bits sont positionnés dans un registre, vous devez exécuter la commande ERRSTR? répétitivement pour lire et remettre à 0 tous les bits positionnés, l'un après l'autre. Une fois que tous les bits positionnés ont été lus et remis à 0 (ou si aucun bit n'était positionné dans aucun des deux registres), la commande ERRSTR? renvoie 0, "NO ERROR". Lorsque les registres d'erreur et auxiliaire sont tous deux initialisés (remis à 0), le bit d'erreur du registre d'état (bit 5) est également remis à 0.
- Lorsque le bit 0 du registre d'erreur est positionné, cela signifie que un ou plusieurs bits sont positionnés dans le registre d'erreur auxiliaire. Dans ce cas, la commande ERRSTR? commence par lire et remettre à 0 les bits positionnés dans le registre d'erreur auxiliaire. Lorsque toutes les erreurs du registre auxiliaire ont été lues et remises à 0, le bit 0 du registre d'erreur est mis à 0 et la commande ERRSTR? peut être utilisée pour lire les éventuelles erreurs restantes dans le registre d'erreur.
- **Commandes connexes:** AUXERR?, EMASK, ERR?, QFORMAT

Exemple

```
10 OPTION BASE 1           ! BORNE INFERIEURE OU TABLEAU A 1
20 DIM A$(200)             ! DIMENSIONNE LA VARIABLE ALPHANUMERIQUE
30 OUTPUT 722;"ERRSTR?"    ! LIT LE MESSAGE D'ERREUR
40 ENTER 722; A,A$         ! ENTRE LA VALEUR NUMERIQUE DANS A; LA
45                          ! CHAINE DANS AS
50 PRINT A,A$              ! IMPRIME LES RESPONSES
```

```
60 IF A>0 THEN GOTO 30    ! BOUCLE POUR CHAQUE ERREUR
70 END
```

EXTOUT

External output. La commande EXTOUT spécifie l'événement qui générera un signal sur le connecteur **Ext Out** du panneau arrière (signal EXTOUT). Cette commande spécifie également la polarité du signal EXTOUT.

Syntaxe

EXTOUT [événement][,polarité]

événement Les choix d'événement sont:

Paramètre événement	Équivalent numérique	Description
OFF	0	Aucun; EXTOUT est invalide
ICOMP	1	Entrée terminée (génère une impulsion de 1 µs dès que le convertisseur A/N a intégré chaque lecture ou, pour l'échantillonnage direct ou le sous-échantillonnage, dès que l'échantillonneur-bloqueur a acquis le signal d'entrée).
ONCE	2	Génère une impulsion de 1 µs dès que la commande EXTOUT ONCE est exécutée; l'événement devient alors OFF
APER	3	Signal d'ouverture (niveau qui indique quand le convertisseur A/N effectue une mesure)
BCOMP	4	Groupe de lectures termine (génère une impulsion de 1 µs à la fin d'un groupe de lectures)
SRQ	5	Événement d'état (génère une impulsion de 1 µs à chaque fois qu'un événement du registre d'état valide pour générer une demande de service se produit). (Voir deuxième point important ci-dessous)
RCOMP	6	Lecture terminée (génère une impulsion de 1 µs après chaque lecture)

Événement à la mise sous tension = ICOMP

Événement par défaut = ICOMP

polarité Spécifie la polarité du signal EXTOUT. Les choix sont:

Paramètre polarité	Équivalent numérique	Description
NEG	0	Génère un signal TTL descendant
POS	1	Génère un signal T:L ascendant

Polarité à la mise sous tension = NEG

Polarité par défaut = NEG

Points importants

- Tous les événements, excepte APER. génère une impulsion de 1 µs sur le correcteur EXTOUT. Le front du signal EXTOUT est la réponse a l'événement Pour plus de détails sur les événements mentionnes ci-dessus, se reporter a **Le Signal EXTOUT** dans le **chapitre 4**.
- Lorsqu'un événement d'état positionne le bit SRQ du registre d'état, celui-ci reste positionne tant qu'il n'est pas réinitialise (commande CSB par exemple). Lorsqu'elle est spécifiée, l'impulsion EXTOUT SRQ est générée a chaque fois qu'un événement d'état, préalablement valide pour générer une demande de service (commande RQS), se produit. L'impulsion EXTOUT SRQ n'est pas systématiquement générée lorsque le bit SRQ est positionne mais lorsque un événement d'état valide se produit.
- **Commande d'interrogation:** La commande d'interrogation EXTOUT? renvoie deux réponses, séparées par une virgule. La première réponse indique l'événement EXTOUT couramment spécifié; la seconde indique la polarité. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** NRDGS, SRQ, STB?, SWEEP, TBUFF

Exemple

```
OUTPUT 722;"EXTOUT APER" !EVENEMENT EXTOUT = FORME D'ONDE
!D'OUVERTURE
```


FIXEDZ

La commande FIXEDZ (impédance fixée) valide ou invalide la fonction d'impédance d'entrée fixe pour les mesures de tension continue. Si elle est validée, le 3458A conserve une impédance d'entrée de 10 mégaohms pour toutes les gammes. Cela évite d'affecter les mesures de tension continue par un changement d'impédance d'entrée intempestif (provoqué par un changement de gamme).

Syntaxe

FIXEDZ [*contrôle*]

contrôle Les valeurs possibles du paramètre *contrôle* sont:

Paramètre <i>contrôle</i>	Équivalent numérique	Description	Impédances d'entrée	
			Gammes DCV 0,1 V, 1 V, 10 V	Gammes DCV 100, 1000 V
OFF	0	FIXEDZ invalidé	>10 GΩ	10 MΩ
ON	1	FIXEDZ validé	10 MΩ	10 MΩ

Contrôle à la mise sous tension = OFF.

Contrôle par défaut = ON.

Points importants

- FIXEDZ reste validé quand vous passez des mesures de tension continue aux mesures de résistances 2- ou 4-fils. Les mesures de résistance effectuées avec FIXEDZ validé seront erronées car la résistance d'entrée du multimètre (10 MΩ) est en parallèle avec les bornes d'entrée.
- FIXEDZ est temporairement invalidé quand vous passez des mesures de tension continue aux mesures de tension alternative, alternative + continue, de courant, de fréquence, ou de période. Par exemple, si FIXEDZ est validé et que vous passez des mesures de tension continue aux mesures de tension alternative, FIXEDZ est invalidé. Quand vous revenez aux mesures de tension continue, cependant, FIXEDZ est de nouveau validé.

- **Commande d'interrogation:** La commande d'interrogation FIXEDZ? renvoie le mode d'impédance d'entrée courante. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** DCV, FUNC, OHM, OHMF,

Exemple

```
OUTPUT 722; "FIXEDZ ON" !VALIDE IMPEDANCE FIXE
```

FREQ

Frequency. La commande FREQ demande au multimètre de mesurer la fréquence du signal d'entrée. Vous devez spécifier si le signal d'entrée est une tension alternative, une tension alternative + continue, un courant alternatif, ou un courant alternatif + continu à l'aide de la commande FSOURCE.

Syntaxe

```
FREQ [entrée_max][, %_resolution]
```

entrée_max Sélectionne une gamme fixe ou le mode gamme automatique. Les gammes correspondent au type de signal d'entrée spécifié dans la commande FSOURCE. Si par exemple le signal d'entrée est une tension alternative, le paramètre *entrée_max* spécifie une gamme de tensions alternatives. Pour sélectionner une gamme fixe, spécifiez l'*entrée_max* comme la valeur absolue (pas de valeurs négatives) de la valeur crête attendue du signal d'entrée. Voir commande **FUNC** ou **RANGE** pour connaître les gammes disponibles pour chaque type de signal d'entrée.

Pour sélectionner le mode de gamme automatique, spécifiez AUTO ou le paramètre par défaut pour *Entrée_max*. Dans le mode de gamme automatique, le multimètre échantillonne le signal d'entrée avant chaque mesure et sélectionne la gamme appropriée.

Entrée_max à la mise sous tension = non applicable.

Entrée_max par défaut = AUTO.

%_resolution Le paramètre *%_resolution* spécifie le nombre de chiffres de résolution et le temps de porte, comme illustré ci-dessous (*%_resolution* affecte également la vitesse de lecture; voir "**Annexe A : Spécifications**" à la page 411 pour plus de détails).

Paramètre %_resolution	Sélectionne le temps de porte	Résolution (en nombre de chiffres)
0,00001	1 s	7
0,0001	100 ms	7
0,001	10 ms	6
0,01	1 ms	5
0,1	100 µs	4

%_resolution à la mise sous tension = non applicable.

%_resolution par défaut= 0,00001

Points importants

- La vitesse de lecture correspond à 1 période du signal d'entrée, au temps de porte ou à la temporisation de lecture par défaut de 1,2 secondes (valeur la plus grande des trois).
- Les mesures de fréquence (et de période) utilisent les circuits de détection de niveau pour déterminer quand le signal d'entrée passe par une tension particulière sur sa pente positive ou négative. (C'est la raison pour laquelle vous ne pouvez pas utiliser l'événement de déclenchement ou d'échantillonnage LEVEL ou l'événement de déclenchement UNE lorsque vous mesurez des fréquences ou des périodes). La valeur de déclenchement par niveau à la mise sous tension ou par défaut sélectionne 0 volt, pente positive. Vous pouvez modifier la tension de déclenchement à l'aide de la commande LEVEL et la pente (positive ou négative) à l'aide de la commande SLOPE.
- Le chiffre de poids fort (qui est un 1/2 chiffre pour la plupart des fonctions de mesure) est un chiffre entier (0-9) pour les mesures de fréquence.
- Les lectures avec la gamme automatique validée sont plus longues car le signal d'entrée est échantillonné (pour déterminer la gamme adéquate) entre chaque lecture.
- Pour les mesures de fréquence (ou de période), une indication de surcharge signifie que l'amplitude de la tension ou du courant est trop forte pour la gamme spécifiée. Cela ne signifie pas que la fréquence (ou la période) appliquée est trop grande pour être mesurée.

- **Commandes connexes:** ACBAND, FSOURCE, FUNC, LFILTER, PER, RES

Exemple

```
10 OUTPUT 722;"FSOURCE ACI"      !SELECTIONNE LE COURANT
15                                !ALTERNATIF COMME SOURCE D'ENTREE
20 OUTPUT 722;"FREQ .01,.001"    !SELECTIONNE LES MESURES DE
25                                !FREQUENCE, GAMME 10 mA, TEMPS DE PORTE
27                                !10 ms, 5 CHIFFRES DE RESOLUTION
30 END
```

FSOURCE

Frequency source. La commande FSOURCE spécifie le type de signal à utiliser pour les mesures de fréquence ou de période.

Syntaxe

```
FSOURCE [source]
```

source Les valeurs possibles du paramètre *source* sont:

Paramètre <i>source</i>	Équivalent numérique	Description
ACV	2	Tension alternative (FREQ 1 Hz - 10 MHz; PER 100 ns - 1 s)
ACDCV	3	Tension alternative + continue (FREQ 1 Hz - 10 MHz; PER 100 ns - 1 s)
ACI	7	Courant alternatif (FREQ 1 Hz - 100 kHz; PER 10 µs - 1 s)
ACDCI	8	Courant alternatif+ continu (FREQ 1 Hz - 100 kHz; PER 10 µs - 1 s)

Source à la mise sous tension = ACV.

Source par défaut = ACV.

Points importants

- **Commande d'interrogation:** Commande d'interrogation. La commande d'interrogation FSOURCE? renvoie la source de fréquence courante. Pour plus

de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.

- **Commandes connexes:** **FREQ**, **FUNC**, **PER**

Exemple

```
10 OUTPUT 722;"FSOURCE ACDCI" !SELECTIONNE LE COURANT ALTERNATIF +
15                               !CONTINU COMME SOURCE D'ENTREE
20 OUTPUT 722;"FREQ .1,.9=01" !SELECTIONNE LES MESURES DE FREQUENCE,
25                               !GAMME 100 mA, TEMPS DE PORTE 1 ms,
27                               !4 CHIFFRES DE RESOLUTION
30 END
```

FUNC

Function. La commande FUNC (fonction) sélectionne le type de mesure (tension alternative, courant continu, etc). Elle vous permet également de spécifier la gamme de mesure et la résolution. (L'en-tête FUNC est optionnel et peut être omis).

Syntaxe

```
FUNC [fonction][,entrée_max.][,%_resolution]
```

ou

```
[FUNC] fonction[,entrée_max][,%_resolution]
```

fonction Le paramètre *fonction* désigne le type de mesure. Les valeurs possibles du paramètre sont:

Paramètre <i>fonction</i>	Équivalent numérique	Description
DCV	1	Mesures de tension continue
ACV	2	Mesures de tension alternative (le mode est déterminé par la commande SETACV)
ACDCV	3	Mesures de tension alternative+ continue (le mode est déterminé par la commande SETACV)
OHM	4	Mesures de résistances 2-fils

Paramètre fonction	Équivalent numérique	Description
OHMF	5	Mesures de résistances 4-fils
DCI	6	Mesures de courant continu
ACI	7	Mesures de courant alternatif
ACDCI	8	Mesures de courant alternatif+ continu
FREQ ^[a]	9	Mesures de fréquence
PER ^[a]	10	Mesures de période
DSAC ^[a]	11	Échantillonnage direct, couplage CA
DSDC ^[a]	12	Échantillonnage direct, couplage CC
SSAC ^[a]	13	Sous-échantillonnage, couplage CA
SSDC ^[a]	14	Sous-échantillonnage, couplage CC

[a] Ces fonctions requièrent des explications supplémentaires et sont décrites individuellement dans ce chapitre.
Pour plus de détails à ce sujet, voir commande **DSAC**, **DSDC**, **FREQ**, **PER**, ou **SSAC**, **SSDC**.

fonction à la mise sous tension = DCV.

fonction par défaut = DCV.

entrée_max. Le paramètre entrée max. sélectionne une gamme standard ou le mode de gamme automatique. Pour sélectionner une gamme standard, spécifiez l'entrée max. comme valeur absolue (pas de chiffres négatifs) de l'amplitude maximale attendue du signal d'entrée (ou la résistance maximale pour les mesures de résistance). Le 3458A sélectionne alors la gamme adéquate.

Pour sélectionner le mode de gamme automatique, spécifiez AUTO pour entrée max. ou demandez le paramètre par défaut. Dans le mode de gamme automatique, le 3458A échantillonne le signal d'entrée avant chaque mesure et sélectionne la gamme appropriée.

Pour DCV:

<i>Paramètre entrée_max</i>	<i>Sélectionne gamme</i>	<i>Pleine échelle</i>
-1 ou AUTO	Gamme Auto.	
0 à 0,12	100 mV	120 mV
>0,12 à 1,2	1 V	1,2 V
>1,2 à 12	10 V	12 V
>12 à 120	100 V	120 V
>120 à 1E3	1000 V	1050 V

Pour ACV ou ACDCV:

<i>Paramètre entrée_max</i>	<i>Sélectionne gamme</i>	<i>Pleine échelle</i>
-1 ou AUTO	Gamme Auto.	
0 à 0,012	10 mV	12 mV
>0,012 à 0,12	100 mV	120 mV
>0,12 à 1,2	1 V	1,2 V
>1,2 à 12	10 V	12 V
>12 à 120	100 V	120 V
>120 à 1E3	1000 V	1050 V

Pour OHM ou OHMF:

<i>Paramètre entrée_max</i>	<i>Sélectionne gamme</i>	<i>Pleine échelle</i>
-1 ou AUTO	Gamme Auto.	
0 à 12	10 Ω	12 Ω
>12 à 120	100 Ω	120 k Ω
>120 à 1,2E3	1 k Ω	1,2 k Ω
>1,2E3 à 1,2E4	10 k Ω	12 k Ω
>1,2E4 à 1,2E5	100 k Ω	120 k Ω
>1,2E5 à 1,2E6	1 M Ω	1,20 M Ω
>1,2E6 à 1,2E7	10 M Ω	12 M Ω
>1,2E7 à 1,2E8	100 M Ω	120 M Ω
>1,2E8 à 1,2E9	1 G Ω	1,2 G Ω

Pour DCI:

<i>Paramètre entrée_max</i>	<i>Sélectionne gamme</i>	<i>Pleine échelle</i>
-1 ou AUTO	Gamme Auto.	
0 à 0,12E-6	0,1 μ A	0,12 μ A
>0,12E-6 à 1,2E-6	1 μ A	1,2 μ A
>1,2E-6 à 12E-6	10 μ A	12 μ A
>12E-6 à 120E-6	100 μ A	120 μ A
>120E-6 à 1,2E-3	1 mA	1,2 mA
>1,2E-3 à 12E-3	10 mA	12 mA
>12E-3 à 120E-3	100 mA	120 mA
>120E-3 à 1,2	1 A	1,05 A

Pour ACI ou ACDCI:

Paramètre entrée_max	Sélectionne gamme	Pleine échelle
-1 ou AUTO	Gamme Auto.	
0 à 120E-6	100 µA	120 µA
>120E-6 à 1,2E-3	1 mA	1,2 mA
>1,2E-3 à 12E-3	10 mA	12 mA
>12E-3 à 120E-3	100 mA	120 mA
>120E-3 à 1,2	1 A	1,05 A

Pour SSAC ou SSDC:

Paramètre entrée_max	Sélectionne gamme	Pleine échelle
0 à 0,012	10 mV	12 mV
>0,012 à 0,120	100 mV	120 mV
>0,120 à 1,2	1 V	1,2 V
>1,2 à 12	10 V	12 V
>12 à 120	100 V	120 V
>120 à 1E3	1000 V	1050 V

Pour DSAC ou DSDC:

Paramètre entrée_max	Sélectionne gamme	Pleine échelle	
		Format SINT	Format DINT
0 à 0,012	10 mV	12 mV	50 mV
>0,012 à 0,120	100 mV	120 mV	500 mV
>0,120 à 1,2	1 V	1,2 V	5.0 V
>1,2 à 12	10 V	12 V	50 V
>12 à 120	100 V	120 V	500 V
>120 à 1E3	1000 V	1050 V	1050 V

Entrée_max à la mise sous tension = AUTO.

Entrée_max par défaut = AUTO.

%_resolution Pour la plupart des fonctions de mesure, vous spécifiez le paramètre **%_resolution** comme un pourcentage du paramètre d'entrée max. (Le paramètre **%_resolution** affecte les mesures de fréquence et de période; voir commandes **FREQ** et **PER** respectivement **%_resolution** est ignoré lorsque le paramètre fonction est DSAC, DSDC, SSAC ou SSDC).

Pour toutes les fonctions, exceptées FREQ. PER, DSAC, DSDC, SSAC et SSDC, le multimètre multiplie **%_resolution** par l'entrée_max pour déterminer la résolution de la mesure. Supposons par exemple que vous mesuriez une tension continue, que l'entrée maximale attendue soit de 10 V et que vous vouliez une résolution de 1 mV. Pour déterminer le paramètre **%_resolution**, utilisez l'équation:

$\%\_resolution = (\text{résolution actuelle} / \text{entrée max}) \times 100$

Pour cet exemple, l'équation donne:

$\%\_resolution = (0,001/10) \times 100 = 0,0001 \times 100 = 0,01$

REMARQUE

Quand vous utilisez la gamme automatique, le multimètre multiplie le paramètre $\%\_resolution$ par la lecture pleine échelle de la gamme sélectionnée. Le résultat est la résolution minimale. Le multimètre vous donne toujours au moins la résolution minimale et, dans de nombreux cas, vous donne un chiffre de résolution supplémentaire.

$\%\_resolution$ à la mise sous tension = aucun: A la mise sous tension, la résolution est déterminée par la commande NPLC qui donne 8,5 chiffres. (La valeur de mise sous tension de la commande NDIG masque 1 chiffre d'affichage; le multimètre n'affiche donc que 7,5 chiffres. Vous pouvez utiliser la commande NDIG 8 pour afficher les 8,5 chiffres; pour plus de détails à ce sujet, voir commande **NDIG**).

$\%\_resolution$ par défaut:

Pour les mesures de fréquence ou de période, le paramètre $\%\_resolution$ par défaut est de 0,00001, ce qui sélectionne un temps de porte de 1 s et 7 chiffres de résolution.

Pour les mesures de tension alternative ou alternative + continue (ACV ou ACDCV), le paramètre $\%\_resolution$ par défaut est de 0,01 pour SETACV SYNC (méthode de mesure synchrone) ou de 0,4% pour SETACV RNDM (méthode de mesure aléatoire).

Pour toutes les autres fonctions de mesure, la résolution par défaut est déterminée par le temps d'intégration courant.

Points importants

- **Commande d'interrogation:** La commande d'interrogation FUNC? renvoie deux réponses, séparées par une virgule. La première réponse correspond à la fonction de mesure courante. La seconde réponse est la gamme de mesure courante (il s'agit de la gamme réelle et pas obligatoirement la valeur spécifiée pour *entrée_max*). La commande d'interrogation FUNC? n'indique pas le mode de gamme automatique courant. Pour le connaître, envoyez la commande ARANGE?. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.

- **Commandes connexes:** ACDCI, ACDCV, ACI, ACV, APER, DCI, DCV, DSAC, DSDC, FREQ, OHM, OHMF, PER, RATIO, NPLC, RES, SETACV, SSAC, SSDC

Exemples

Dans le programme suivant, la ligne 10 laisse le *%_resolution* de la ligne 20 contrôler la résolution. La résolution spécifiée par la ligne 20 est de $6\text{ V} \times 0,0000167 = 100\text{ }\mu\text{V}$.

```
10 OUTPUT 722;"NPLC 0"           !PLCS AU MINIMUM
20 OUTPUT 722;"FUNC DCV,6,.00167" !TENSION CONTINUE, 6V MAX,
25                               !RESOLUTION 100 µV
30 END
```

Dans le programme suivant, la ligne 10 fixe le nombre de PLC (périodes secteur) à 1000. Ceci correspond à la résolution maximale (7,5 chiffres) et empêche le *%_resolution* de la ligne 20 d'affecter la mesure. La résolution demandée à la ligne 20 est de $10\text{ m}\Omega$.

Mais à cause de la ligne 10, la résolution réelle est de $100\text{ }\mu\Omega$.

```
10 OUTPUT 722;"NPLC 1000"       !PLC AU MAXIMUM
20 OUTPUT 722;"FUNC OHM,1E3,.001" !RESISTANCE 2 FILS,
25                               !1 kΩ MAX, RESOLUTION 10 mΩ
30 END
```

ID?

Identity query. Le multimètre répond à la commande d'interrogation ID? en envoyant la chaîne "Keysight 3458A". Cette commande permet au contrôleur de localiser le multimètre par son adresse.

Syntaxe

ID?

Points importants

- **Commandes connexes:** ADDRESS, QFORMAT

Exemple

```
10 OUTPUT 722;"ID?" !RETOURNE LA REPONSE
20 ENTER 722;A$     !ENTRE LA REPONSE DANS LA VARIABLE A$ DE
25                 !L'ORDINATEUR
```

```
30 PRINT A$      !IMPRIME LA REPONSE
40 END
```

INBUF

Input buffer. La commande INBUF valide ou invalide la mémoire-tampon d'entrée du multimètre. Lorsqu'elle est validée, la mémoire-tampon d'entrée enregistre temporairement les commandes qu'elle reçoit par le bus GPIB. Cela libère le bus GPIB immédiatement après la réception de la commande, ce qui laisse le contrôleur libre d'effectuer d'autres tâches pendant que le multimètre exécute les commandes enregistrées.

Syntaxe

INBUF [*contrôle*]

contrôle Les valeurs possibles du paramètre *contrôle* sont:

Paramètre <i>contrôle</i>	Équivalent numérique	Description
OFF	0	Invalide la mémoire-tampon d'entrée; les commandes ne sont acceptées que lorsque le multimètre n'est pas occupé.
ON	1	Valide la mémoire-tampon d'entrée; les commandes sont enregistrées, ce qui libère le bus immédiatement.

Contrôle à la mise sous tension = OFF.

Contrôle par défaut = ON.

Points importants

- L'invalidation de la mémoire-tampon d'entrée dégrade légèrement la performance de vitesse mais permet de mieux synchroniser l'activité du bus. Quand la mémoire-tampon d'entrée est invalidée (OFF), le multimètre n'accepte qu'une seule commande à la fois et ne libère pas le bus tant qu'il n'a pas fini d'exécuter sa commande. Ainsi, les commandes suivantes envoyées à d'autres appareils raccordés au bus ne peuvent pas s'exécuter tant que le multimètre n'a pas terminé d'exécuter sa ou ses commandes.

- Quand la mémoire-tampon d'entrée est validée (ON), le multimètre enregistre les commandes et libère le bus GPIB dès que la transmission des messages est terminée. Ceci permet au contrôleur de communiquer avec d'autres appareils raccordés au bus pendant que le multimètre exécute sa ou ses commandes. La synchronisation avec les autres appareils du bus risque toutefois d'être perdue s'ils exécutent leurs instructions avant que le multimètre n'ait le temps d'exécuter les siennes. Il est conseillé dans ce cas de surveiller le bit Prêt du registre d'état (à l'aide d'une interrogation série) pour déterminer quand le multimètre a fini.
- La mémoire-tampon d'entrée du multimètre peut contenir jusqu'à 255 caractères. Lorsqu'elle est pleine, le multimètre retient le bus pendant qu'il exécute les premières commandes reçues. Le reste du message est enregistré en mémoire dès que de la place est libérée et ce n'est que lorsque tout le message est enregistré que le bus est libéré.
- **Commande d'interrogation:** La commande d'interrogation INBUF? retourne le mode courant de la mémoire-tampon d'entrée. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.

Exemple

Le programme suivant valide la mémoire-tampon d'entrée avant d'exécuter toutes les routines d'étalonnage automatique. Ceci empêche le bus d'être retenu pendant que les routines d'étalonnage s'exécutent. ce qui prend environ 11 minutes.

```
10 OUTPUT 722;"INBUF ON" !VALIDE LA MEMOIRE-TAMPON D'ENTREE
20 OUTPUT 722;"ACAL ALL" !ETALONNAGE AUTOMATIQUE (PREND>
21                               !11 MINUTES
30 END
```

ISCALE?

Integer scale query. La commande ISCALE? renvoie le facteur d'échelle des lectures au format de sortie SINT ou DINT.

Syntaxe

ISCALE?

Points importants

- Le facteur d'échelle est toujours 1 pour les formats de sortie ASCII, SREAL ou DREAL.
- Les lectures envoyées au format de sortie SINT ou DINT (voir commande **OFORMAT**) sont d'abord comprimées par le multimètre pour qu'elles puissent être exprimées sous forme d'entiers. Le fait de multiplier les lectures par la valeur retournée par ISCALE? les restitueront à leurs valeurs réelles. Le facteur d'échelle est déterminé par la configuration du multimètre (fonction de mesure, gamme et temps d'intégration) lorsque ISCALE? est exécuté. Il est donc très important que le multimètre soit configuré comme il l'était pour les lectures au moment où le facteur d'échelle est extrait. Vous pouvez extraire le facteur d'échelle après que le multimètre ait été configuré mais avant que les lectures ne soient déclenchées ou immédiatement après les lectures.
- Il n'est pas conseillé d'utiliser le format de mémoire ou de sortie SINT ou DINT pour les mesures de fréquence ou de période; lorsqu'une fonction mathématique différée est validée (à l'exception de STAT et PFAIL) ou lorsque le changement de gamme automatique est validé.
- **Commandes connexes:** OFORMAT, SSAC, SSDC

Exemples

Exemple SINT

Le programme suivant transmet 10 lectures au format SINT, extrait le facteur d'échelle et multiplie chaque lecture par le facteur d'échelle.

```

10 OPTION BASE 1                                ! BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Int_rdgs (1:10) BUFFER               ! CREATION DU TABLEAU
25                                              ! DES ENTIERS EN MEMOIRE-TAMPON
30 REAL Rdgs(1:10)                             ! CREATION DU TABLEAU DES REELS
40 Num_readings=10                             ! NOMBRE DE LECTURES = 10
50 ASSIGN @Dvm TO 722                          ! AFFECTATION DE L'ADRESSE DU MULTIMETRE
60 ASSIGN @Int_rdgs TO BUFFER Int_rdgs(*) ! AFFECTATION
65                                              ! DU NOM D'ACCES DE LA MEMOIRE-TAMPON
70 OUTPUT @Dvm;"PRESET NORM;OFORMAT SINT;NPLC 0;NRDGS ";Num_readings
75      ! TARM AUTO, TRIG SYN, FORMAT DE SORTIE SINT, TEMPS
77      ! D'INTEGRATION MIN.
80 TRANSFER @Dvm TO @Int_rdgs;WAIT ! EVENEMENT SYN,
```

```

82      ! TRANSFERT DES LECTURES DANS LE TABLEAU DES ENTIERS;
85      ! PAS DE CONVERSION DE DONNEES REQUISES PUISQUE LE
87      ! FORMAT INTEGER DE L'ORDINATEUR EST IDENTIQUE A SINT
88      ! (MAIS TABLEAUX DES ENTIERS REQUIS)
90 OUTPUT @Dvm;"ISCALE?"          ! INTERROGATION DU FACTEUR
95                                ! D'ECHELLE POUR LE FORMAT SINT
100 ENTER @Dvm;S                  ! LECTURE DU FACTEUR D'ECHELLE
110 FOR I=1 TO Num_readings
120 Rdgs(I)=Int_rdgs(I)           ! CONVERSION DE CHAQUE LECTURE DU FORMAT
125      ! ENTIER-AU FORMAT REEL (OBLIGATOIRE POUR EVITER
127      ! UN DEPASSEMENT ENTIER SUR LA LIGNE SUIVANTE)
130 R=ABS(Rdgs(I))                ! UTILISATION DE LA VALEUR
135                                ! ABSOLUE POUR VERIFIER SURCHARGE
140 IF R>=32767 THEN PRINT "OVLD" ! SI SURCHARGE, IMPRESSION
145                                ! D'UN MESSAGE
150 Rdgs(I)=Rdgs(I)*S             ! MULTIPLICATION DE LA LECTURE PAR LE
155                                ! FACTEUR D'ECHELLE
160 Rdgs(I)=DROUND(Rdgs(I),4)     ! VALEUR ARRONDIE A 4 CHIFFRES
170 NEXT I
180 END

```

Exemple DINT

L'exemple suivant est identique au précédent à part qu'il effectue 50 lectures au lieu de 10 et les transmet à l'ordinateur en utilisant le format DINT.

```

10 OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Num_readings,I,J,K    ! DECLARATION DES VARIABLES
30 Num_readings=50               ! NOMBRE DE LECTURES = 50
40 ALLOCATE REAL Rdgs(1:Num_readings) ! CREATION D'UN TABLEAU POUR LES
45                               ! LECTURES
50 ASSIGN @Dvm TO 722            ! AFFECTATION DE L'ADRESSE DU MULTIMETRE
60 ASSIGN @Buffer TO BUFFER[4*Num_readings] ! AFFECTATION DU NOM
65                               ! D'ACCES DE LA MEMOIRE-TAMPON
70 OUTPUT @Dvm;"PRESET NORM;RANGE 10;OFORMAT DINT;NRDGS ";Num_readings
75 ! TARM AUTO, TRIG SYN, DCV GAMME 10 V, FORMAT DE SORTIE DINT,
77 ! 50 LECTURES,AUTO
80 TRANSFER @Dvm TO @Buffer;WAIT ! EVENEMENT SYN, TRANSFERT DES
85                               ! LECTURES
90 OUTPUT @Dvm;"ISCALE?"        ! INTERROGATION DU FACTEUR D'ECHELLE POUR
95                               ! LE FORMAT DINT
100 ENTER @Dvm;S                ! LECTURE DU FACTEUR D'ECHELLE
110 FOR I=1 TO Num_readings
120 ENTER @Buffer USING "#,W,W";J,K ! ENTRER UN MOT DE 16 OCTETS
122 ! NOTATION COMPLEMENT A 2 DANS CHAQUE VARIABLE J ET K (# = FIN
125 ! D'INSTRUCTION NON REQUISE; W = METTRE DONNEES SOUS FORME ENTIER
127 ! 16 BITS NOTATION COMPLEMENT A 2)
130 Rdgs(I)=(J*65536.+K+65536.*(K<0)) ! CONVERTIR EN NB REEL
140 R=ABS(Rdgs(I))               ! UTILISATION DE LA VALEUR ABSOLUE POUR
145                               ! VERIFIER SURCHARGE
150 IF R>2147483647 THEN PRINT "OVLD" ! SI SURCHARGE, IMPRESSION
155                               ! D'UN MESSAGE
160 Rdgs(I)=Rdgs(I)*S            ! APPLICATION DU FACTEUR D'ECHELLE
170 Rdgs(I)=DROUND(Rdgs(I),8)    ! ARRONDIT LECTURE CONVERTIE
180 PRINT Rdgs(I)               ! IMPRESSION DES LECTURES
190 NEXT I
200 END

```

LEVEL

La commande LEVEL spécifie le niveau de la tension de déclenchement (sous forme de pourcentage de la gamme courante) et le couplage (CA ou CC) pour les déclenchements par niveau. Un événement de déclenchement par niveau se produit lorsque le signal d'entrée atteint la tension spécifiée sur la pente (positive ou négative) spécifiée parla commande SLOPE.

Syntaxe

LEVEL [*pourcentage*][*,couplage*]

pourcentage Spécifie le pourcentage de la gamme courante pour un déclenchement par niveau. La gamme valide pour ce paramètre va de -500% à +500%, par incréments de 5% pour l'échantillonnage direct ou le sous-échantillonnage et de -120% à + 120% par incréments de 1% pour les tensions continues (pour plus de détails à ce sujet. se reporter au [chapitre 5](#)).

Pourcentage à la mise sous tension = 0% (0 V).

Pourcentage par défaut = 0% (0 V).

En échantillonnage direct, les valeurs de pleine échelle correspondent à 500% (5 fois) des gammes de 10 mV, 100 mV, 1V, 10V et 100V. Lorsque vous spécifiez le pourcentage auquel se produira le déclenchement, utilisez un pourcentage de la gamme. Supposons que le signal d'entrée ait une valeur crête de 20 V par exemple et que vous utilisiez la gamme 10 V. Pour provoquer un déclenchement à 15 V, vous devez spécifier 150% (commande LEVEL 150).

couplage Le paramètre couplage sélectionne le couplage du signal par rapport aux circuits de détection de niveau uniquement. Ce paramètre n'affecte pas le couplage du signal mesuré.

Paramètre <i>coupling</i>	Équivalent numérique	Description
DC	1	Entrée à couplage CC (par rapport aux circuits de détection de niveau)
CA	2	Entrée à couplage CA (par rapport aux circuits de détection de niveau)

Couplage à la mise sous tension = CA

Couplage par défaut = CA

Points importants

- Le déclenchement par niveau peut être utilisé pour les mesures de tensions continues, pour l'échantillonnage direct et le sous-échantillonnage. Pour les tensions continues et l'échantillonnage direct, le déclenchement par niveau peut être utilisé comme événement de déclenchement (commande TRIG LEVEL) ou d'échantillonnage (commande NRDGS *n*, LEVEL). Pour le sous-échantillonnage, le déclenchement par niveau ne peut être utilisé que comme événement Source de synchronisation (commande SSRC LEVEL).
- La fonction de zéro automatique doit être invalidée (AZERO OFF) lorsque le déclenchement par niveau est utilisé pour les mesures de tension continue. (Le zéro automatique ne s'applique ni à l'échantillonnage direct ni au sous-échantillonnage).
- **Commande d'interrogation**: La commande d'interrogation LEVEL? renvoie deux réponses, séparées par une virgule. La première réponse est le pourcentage couramment spécifié. La seconde réponse est le mode de couplage courant. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes**: DCV, DSAC, DSDC, LFILTER, NRDGS, SETACV, SYNC, SLOPE, SSAC, SSDC, SSRC, TRIG

Exemple

```

10 OUTPUT 722;"TARM HOLD"      !SUSPEND LES DECLENCHEMENTS
20 OUTPUT 722;"PRESET DIG"      !MESURES DE TENSION CONTINUE RAPIDES,
25                               !GAMME 10 V
30 OUTPUT 722;"TRIG LEVEL"      !SELECTIONNE L'EVENEMENT DE
35                               !DECLENCHEMENT PAR NIVEAU
40 OUTPUT 722;"SLOPE POS"       !DECLENCHEMENT SUR PENTE POSITIVE DU
45                               !SIGNAL
50 OUTPUT 722;"LEVEL 50,AC"      !DECLENCHEMENT A 50% DE LA GAMME 10V
55                               !(5V) , COUPLAGE CA
60 END

```

LFILTER

Level filter. La commande LFil..TER valide ou invalide la fonction de filtre de niveau. Lorsqu'elle est validée, cette fonction relie un filtre passe-bas mono-pôle à l'entrée des circuits de détection de niveau. Le filtre passe-bas a un point 3 dB à 75 kHz et empêche les composantes de haute fréquence de provoquer de faux déclenchements.

Syntaxe

LFILTER [*contrôle*]

contrôle Les valeurs possibles pour *contrôle* sont:

Paramètre <i>contrôle</i>	Équivalent numérique	Description
OFF	0	Invalide le filtre de niveau; il n'y a aucun filtrage
ON	1	Valide le filtre de niveau

Contrôle à la mise sous tension = OFF.

Contrôle par défaut = ON.

Points importants

- Le filtre de niveau peut être utilisé pour le déclenchement par niveau des mesures de tensions continues, d'échantillonnage direct et de sous-échantillonnage. D peut également être utilisé pour réduire la sensibilité au bruit du multimètre pour les mesures de fréquence ou de période ou les mesures de tension alternative ou alternative+ continue effectuées à l'aide de la méthode synchrone (commande SETACV SYNC).
- **Commande d'interrogation:** La commande d'interrogation LFILTER? renvoie le mode de filtre de niveau courant Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** DCV, DSAC, DSDC, FREQ, LEVEL, NRDGS, PER, SETACV, SYNC, SLOPE, SSAC, SSDC, SSRC, TRIG

Exemple

OUTPUT 722;"LFILTER ON" !VALIDE LE FILTRE DE NIVEAU

LFREQ

La commande LFREQ vous permet de spécifier la fréquence de référence du convertisseur A/N ou de mesurer la fréquence secteur et de définir la fréquence de référence à la valeur mesurée.

Syntaxe

LFREQ [*fréquence*]

ou

LFREQ LINE

fréquence Vous permet de spécifier la fréquence de référence. La gamme du paramètre fréquence est de 45-65 Hz, ou 360-440 Hz. Lorsque vous spécifiez une fréquence dans la gamme 360-440 Hz, le multimètre divise la valeur spécifiée par 8. Si par exemple vous spécifiez LFREQ 400, le multimètre définit la fréquence de référence à $400/8 = 50$ Hz.

Fréquence de référence à la mise sous tension = valeur arrondie à 50 ou 60 Hz (voir premier point important ci-dessous).

Fréquence de référence par défaut = valeur exacte de la fréquence secteur mesurée (ou valeur mesurée/8 pour une fréquence secteur de 400 Hz).

LINE Mesure la fréquence secteur et définit la fréquence de référence à la valeur mesurée (ou à la valeur mesurée/8 si elle est comprise entre 360 et 440 Hz).

Points importants

- A sa mise sous tension, le multimètre mesure la fréquence secteur, l'arrondit à 50 ou 60 Hz et définit la fréquence de référence du convertisseur A/N à cette valeur arrondie. (Pour une fréquence secteur de 400 Hz, le multimètre utilise 50 Hz - qui est une sous-harmonique de 400 Hz - comme fréquence de référence).
- La taille du pas de la période de la fréquence de référence est de 100 ns. La période d'une fréquence de référence de 60 Hz par exemple est de $1/60$ Hz = 0,01666666... Comme la taille du pas est de 100 ns, le multimètre utilise la valeur 0,01666667 s. La taille du pas se remarque davantage lorsque vous

utilisez la commande d'interrogation LFREQ?. Si par exemple vous avez spécifié 60 Hz comme fréquence de référence, LFREQ? renvoie la valeur 59.99988 (1.,0,0166667).

- Le multimètre multiplie la période de la fréquence de référence par le nombre de périodes secteur spécifié par la commande NPLC pour déterminer le temps d'intégration réel. Pour les mesures continues ou de résistance, le mode de réjection de bruit normal du multimètre (NMR) est lié à la précision de la fréquence de référence du convertisseur A/N.
- **Commande d'interrogation:** La commande d'interrogation LFREQ? renvoie la valeur courante de la référence de fréquence secteur utilisée par le convertisseur A/N du multimètre. Comme la taille du pas est de 100 ns, si la période de la valeur spécifiée n'est pas divisible par 1/100 ns, la valeur retournée par LFREQ? différera légèrement de la valeur spécifiée. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** LINE?, NPLC

Exemple

```
OUTPUT 722; "LFREQ LINE" !MESURE LA FREQUENCE SECTEUR, DEFINIT LA
!FREQUENCE DE REFERENCE A LA VALEUR
!MESUREE (OU VALEUR MESUREE/8 POUR UNE
!FREQUENCE SECTEUR DE 400 Hz)
```

LINE?

Line frequency query. La commande LINE? mesure et retourne la fréquence de l'alimentation secteur.

Syntaxe

LINE?

Points importants

- Voir la commande **LFREQ** (page précédente) où figure un exemple montrant comment mesurer la fréquence secteur et définir automatiquement la fréquence de référence du convertisseur A/N à la valeur mesurée.
- **Commandes connexes:** LFREQ

Exemple

```
10 OUTPUT 722; "LINE?" !MESURE LA FREQUENCE SECTEUR
20 ENTER 722;A          !ENTRE LA REPONSE DANS LA VARIABLE A
30 PRINT A              !IMPRIME LA REPONSE
40 END
```

LOCK

Lockout. La commande LOCK (verrouillage) valide ou invalide le clavier du 3458A.

Syntaxe

LOCK [*contrôle*]

contrôle Les valeurs possibles du paramètre *contrôle* sont:

Paramètre <i>contrôle</i>	Équivalent numérique	Description
OFF	0	Valide le clavier (fonctionnement normal)
ON	1	Invalide le clavier (les touches sont sans effet)

Contrôle à la mise sous tension = OFF.

Contrôle par défaut = ON.

Points importants

- La commande LOCK est accessible à partir du répertoire de commandes alphabétique du panneau avant. Cependant, son exécution à partir du panneau avant est sans effet.
- Après avoir invalidé le clavier, vous ne pouvez le re-valider qu'à partir du contrôleur ou en arrêtant/relançant l'instrument La commande LOCK invalide la touche **Local** du 3458A.
- **Commande d'interrogation:** La commande d'interrogation LOCK? renvoie le mode LOCK courant Pour de plus détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** LOCAL LOCKOUT (commande GPIB)

Exemple

```
OUTPUT 722;"LOCK ON" !INVALIDE LE CLAVIER
```

MATH

La commande MATH valide ou invalide les fonctions mathématiques en temps réel.

Syntaxe

```
MATH [opération_a][,opération_b]
```

opération Les choix possibles pour opération sont:

Paramètre événement	Équivalent numérique	Description
OFF	0	Invalide toutes les opérations mathématiques en temps réel préalablement validées.
CONT	1	Valide l'opération mathématique précédente. Pour revalider les deux opérations précédentes, envoyez MATH CONT,CONT.
CTHRM	3	Résultat = température (°C) d'une thermistance de 5 kΩ (40653B). La fonction doit être OHM ou OHMF (gamme 10 kΩ ou supérieure).
DB	4	Résultat = 20 x log ₁₀ (lecture/registre REF). Le registre REF est initialisé à 1, pour produire des dBV.
DBM	5	Résultat= 10 x log ₁₀ (lecture2/registre RES/1mW). La fonction doit être ACV, DCV ou ACDCV.
FILTER	6	Résultat = sortie du filtre passe-bas numérique pondérée exponentiellement. La réponse est donnée par le registre DEGREE.
FTHRM	8	Résultat = température (°F) d'une thermistance de 5 kΩ (40653B). La fonction doit être OHM ou OHMF (gamme 10 kΩ ou supérieure).
NULL	9	Résultat= lecture - registre OFFSET. Le registre OFFSET est initialement configuré par la première lecture - vous pouvez ensuite le modifier.
PERC	10	Résultat= ((lecture - registre PERC)/registre PERC) x 100.

Paramètre événement	Équivalent numérique	Description
PFAIL	11	Lecture comparée aux registres MAX et MIN.
RMS	12	Résultat = lecture des carrés, s'applique à l'opération FILTER, prend la racine carrée.
SCALE	13	Résultat= lecture - registre OFFSET)/registre SCALE.
STAT	14	Calcule des statistiques sur le jeu de lectures courant et sauvegarde les résultats dans les registres suivants: SDEV = écart-type MEAN= moyenne des lectures NSAMP = nombre de lectures UPPER= plus grande lecture LOWER= plus petite lecture
CTHRM2K	16	Résultat = température (°C) d'une thermistance de 2 k Ω (40653A). La fonction doit être OHM ou OHMF.
CTHRM10K	17	Résultat = température (°C) d'une thermistance de 10 k Ω (40653C). La fonction doit être OHM ou OHMF.
FTHRM2K	18	Résultat = température (°F) d'une thermistance de 2 k Ω (40653A). La fonction doit être OHM ou OHMF.
FTHRM10K	19	Résultat = température (°F) d'une thermistance de 10 k Ω (40653C). La fonction doit être OHM ou OHMLF.
CRTD85	20	Résultat= température (°C) d'un RTD de 100 Ω avec alpha de 0,00385 (40654A ou 40654B). La fonction doit être OHM ou OHMF.
CRTD92	21	Résultat = température (°C) d'un RTD de 100 Ω avec alpha de 0,003916. La fonction doit être OHM ou OHMF.
FRTD85	22	Résultat= température (°F) d'un RTD de 100 Ω avec alpha de 0,00385 (40654A ou 40654B). La fonction doit être OHM ou OHMF.
FRTD92	23	Résultat= température (°F) d'un RTD de 100 Ω avec alpha de 0,003916. La fonction doit être OHM ou OHMF.

Opération a, b à la mise sous tension= OFF,OFF.

Opération a, b par défaut= OFF,OFF.

Valeurs des registres à la mise sous tension = tous les registres sont mis à 0 avec les exceptions suivantes:

DEGREE = 20	REF = 1
SCALE = 1	RES = 50
PERC = 1	

Points importants

- Les opérations mathématiques FILTER, RMS, STAT ou PFAIL sont effectuées sur toutes les lectures qui suivent. Cependant, à chaque fois que la configuration du multimètre est modifiée, les résultats des précédentes opérations mathématiques sont effacés et l'opération (ou les opérations) recommence(nt) sur les nouvelles lectures. Toutes les autres opérations mathématiques restent validées tant que vous n'invalidez pas la fonction mathématique (MATH OFF), que vous ne spécifiez pas d'autres opérations mathématiques à l'aide de la commande MATH ou que vous ne validez pas les opérations mathématiques en différé (sauf MMATH PFAIL ou MMATH STAT. Pour plus de détails à ce sujet, voir commande MMATH).
- Quand deux opérations mathématiques en temps réel sont validées, l'opération a est d'abord effectuée. Ensuite, l'opération b est effectuée sur le résultat de la première opération.
- Si une fonction mathématique en temps réel est validée, le 1/2 chiffre de l'affichage devient un chiffre entier. Ainsi, si vous effectuez des mesures de tension alternative avec 4 chiffres 1/2, puis que vous validez la fonction SCALE, l'affichage pourra montrer 5 chiffres entiers.
- Les registres mathématiques sont configurés avec la commande SMATH. Ils sont lus avec la commande RMATH.
- **Commande d'interrogation:** La commande d'interrogation MATH? renvoie deux réponses, séparées par une virgule, indiquant la (ou les) fonction(s) mathématique(s) en temps réel validée(s). Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** MMATH, RMATH, SMATH

Exemple

Le programme suivant effectue l'opération en temps réel NULL sur 20 lectures. Une fois la commande NULL exécutée, la première lecture est déclenchée par la ligne 50. La valeur du registre OFFSET (décalage) est modifiée à 3.05. Les 20 lectures sont déclenchées par la ligne 90 et la valeur 3.05 est soustraite de chaque lecture.

```

10 OPTION BASE 1           ! BORNE INFERIEURE DU TABLEAU A 1
20 DIM Rdgs(20)           ! DIMENSIONNE LE TABLEAU POUR 20 LECTURES
30 OUTPUT 722;"PRESET NORM" ! PRECONFIGURATION : NRDGS 1,AUTO, DCV 10
40 OUTPUT 722;"MATH NULL"  ! VALIDE LA FONCTION NULL EN TEMPS REEL
50 OUTPUT 722;"TRIG SGL"   ! DECLENCHE 1 LECTURE, ENREGISTREE CANS
55                          ! LE REGISTRE DECALAGE
60 OUTPUT 722;"SMATH OFFSET,3.05" ! ECRIT 3,05 DANS LE REGISTRE
65                          ! DECALAGE
70 OUTPUT 722;"NRDGS 20"   ! 21 LECTURES PAR DECLENCHEMENT
80 OUTPUT 722;"TRIG SYN"   ! EVENEMENT DE DECLENCHEMENT SYNCHRONE
90 ENTER 722;Rdgs(*)       ! EVENEMENT SYNCHRONE, ENTRE LES LECTURE
95                          ! CORRIGEEES PAR LA FONCTION NULL
100 PRINT Rdgs(*)          ! IMPRIME LES LECTURES UNE FOIS CORRIGEEES
105                          ! PAR LA FONCTION NULL
110 END

```

MCOUNT?

Memory count query. La commande MCOUNT? renvoie le nombre de lectures enregistrées en mémoire.

Syntaxe

MCOUNT?

Points importants

- **Commandes connexes:** MEM, MFORMAT, MSIZE, RMEM

Exemple

```

10 OUTPUT 722; "MOUNT?" !RETOURNE LE NOMBRE DE LECTURES
15                        !ENREGISTREES
20 ENTER 722;A          !ENTRE LA REPOSE DANS UNE VARIABLE
30 PRINT A              !IMPRIME LA REPOSE
40 END

```

MEM

Memory. La commande MEM (mémoire) valide ou invalide la mémoire de lecture et désigne le mode d'enregistrement.

Syntaxe

MEM [*mode*]

mode Les valeurs possibles du paramètre *mode* sont:

Paramètre <i>mode</i>	Équivalent numérique	Description
OFF	0	Arrête l'enregistrement des lectures (les lectures enregistrées restent intactes)
LIFO	1	Efface la mémoire de lecture et enregistre les nouvelles lectures LIFO (dernier entré - premier sorti)
FIFO	2	Efface la mémoire de lecture et enregistre les nouvelles lectures FIFO (premier entré - premier sorti)
CONT	3	Laisse la mémoire intacte et sélectionne le mode précédent (s'il n'y avait pas de mode précédent, FIFO est sélectionné)

mode à la mise sous tension = OFF

mode par défaut= FIFO

Points importants

- En mode grande vitesse, lorsque la mémoire de lecture est validée en mode FIFO et remplie, l'événement d'armement de déclenchement devient HOLD, ce qui interrompt les lectures et invalide automatiquement le mode grande vitesse. Après avoir extrait plusieurs ou toutes les lectures de la mémoire, vous

pouvez reprendre les mesures en modifiant l'événement d'armement de déclenchement (commande TARM). Lorsque le multimètre n'est pas en mode grande vitesse et que vous remplissez la mémoire en mode FIFO, les lectures enregistrées restent intactes mais les nouvelles lectures ne sont pas enregistrées. En mode LIFO, les plus anciennes lectures sont remplacées par les plus récentes, que le multimètre soit en mode grande vitesse ou pas.

- Si le contrôleur demande des données du 3458A quand sa mémoire tampon de sortie est vide en mode LIFO ou FIFO, une lecture est retirée de la mémoire et placée dans la mémoire tampon de sortie. C'est la méthode de "lecture implicite" de rappel des lectures. En mode LIFO, la lecture retournée est la plus récente. En mode FIFO, la lecture retournée est la plus ancienne. Le mode d'enregistrement des lectures (LIFO ou FIFO) n'est important que si vous utilisez la méthode de "lecture implicite" pour rappeler les lectures. Le mode d'enregistrement n'a pas d'effet sur les lectures rappelées avec la commande RMEM.
- Le format mémoire (SINT, DINT, ASCD, SREAL ou DREAL) est spécifié avec la commande MFORMAT.
- L'exécution de la commande RMEM invalide la mémoire de lecture (OFF). Pour revalider la mémoire de lecture après un RMEM, vous devez exécuter la commande MEM CONT, MEM FIFO ou MEM LIFO.
- **Commande d'interrogation:** La commande d'interrogation MEM? renvoie le mode de mémoire courant. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** MCOUNT?, MFORMAT, MSIZE, RMEM

Exemple

```
OUTPUT 722;"MEM FIFO" !VALIDE LA MEMOIRE DE LECTURE, MODE FIFO
```

MENU

La commande MENU sélectionne la liste de commandes SHORT ou FULL (abrégée ou complète) dans le menu de commandes alphabétique du panneau avant.

Syntaxe

```
MENU [mode]
```

mode Les valeurs possibles du paramètre *mode* sont:

Paramètre <i>mode</i>	Équivalent numérique	Description
SHORT	0	Sélectionne le menu de commandes «abrégé»
FULL	1	Sélectionne le menu de commandes complet

Mode à la mise sous tension= mode sélectionné au moment où l'instrument a été mis hors tension

Mode par défaut= FULL

Points importants

- Pour accéder au menu de commandes alphabétique, appuyez sur l'une des touches MENU (accès par [Shift]) libellées C, E, L, N, R, Sou T. Vous pouvez ensuite localiser une commande particulière en utilisant les touches fléchées (vers le haut ou vers le bas).
- Le paramètre *mode* est enregistré en mémoire permanente (il n'est pas perdu lorsque l'instrument est mis hors tension).
- Le menu FULL (complet) contient toutes les commandes à l'exception des commandes d'interrogation non standard (commande à la suite de laquelle l'utilisateur ajoute un point d'interrogation. Exemple: BEEP, BEEP?). Le menu SHORT (abrégé) ne contient aucune commande GPIB ni aucune commande accessible par une touche particulière du panneau avant (exemple: commande RSTATE, touche Rappel Etat).
- **Commande d'interrogation:** La commande d'interrogation MENU? renvoie une réponse indiquant le mode de menu courant. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** DEFKEY, LOCK

Exemple

OUTPUT 722;"MENU SHORT" !SELECTIONNE LE MENU "ABREGÉ"

MFORMAT

Memory format. La commande MFORMAT (format mémoire) efface la mémoire de lecture et spécifie le format d'enregistrement des nouvelles lectures.

Syntaxe

MFORMAT [*format*]

format Les valeurs possibles du paramètre *format* sont:

Paramètre <i>format</i>	Équivalent numérique	Description
ASCII	1	ASCII - 16 octets par lecture ^[a]
SINT	2	Entier simple - 16 bits en complément à 2 (2 octets par lecture)
DINT	3	Entier long - 32 bits en complément à 2 (4 octets par lecture)
SREAL	4	Réel simple - (IEEE-754) 32 bits (4 octets par lecture)
DREAL	5	Réel long (IEEE-754) 64 bits (8 octets par lecture)

[a] Le format ASCII comporte en fait 15 octets par lecture plus 1 octet pour un caractère nul qui n'est utilisé que pour séparer les lectures enregistrées au format ASCII.

format à la mise sous tension = SREAL

format par défaut= SREAL

Points importants

- Le multimètre signale une condition de surcharge en enregistrant la valeur $\pm 1\text{E}+38$ en mémoire à la place de la lecture. Lorsque des valeurs de surcharge sont rappelées sur l'affichage, la valeur $\pm 1\text{E}+38$ s'affiche. Lorsque des valeurs de surcharge sont transférées de la mémoire de lecture à la mémoire-tampon de sortie GPIB, elles sont converties à la valeur de surcharge correspondant au format de sortie spécifié. (Pour plus de détails à ce sujet, voir commande **OFORMAT**).
- Quand il utilise le format mémoire SINT ou DINT, le 3458A enregistre chaque lecture en supposant un certain facteur d'échelle. Ce facteur d'échelle est basé sur la fonction de mesure, la gamme, la configuration A/N, et les

fonctions mathématiques validées en cours. De même, quand vous rappelez une lecture, le 3458A calcule le facteur d'échelle en se basant sur la fonction de mesure, la gamme, la configuration A/N, et les fonctions mathématiques validées. Il multiplie alors le facteur d'échelle par la lecture enregistrée et envoie le résultat (lecture rappelée) sur l'affichage ou dans la mémoire tampon de sortie. Par conséquent, assurez-vous que la configuration du 3458A est la même pendant l'enregistrement et le rappel des données en format SINT ou DINT.

- Il n'est pas conseillé d'utiliser le format de sortie ou de mémoire SINT ou DINT pour les mesures de fréquence ou de période; lorsqu'une opération mathématique (en temps réel ou différé) est validée (sauf STAT et PFAIL); ou encore lorsque la fonction de changement de gamme automatique est validée.
- Le format mémoire n'affecte pas le format de sortie spécifié par la commande OFORMAT.
- La mémoire de lecture est validée avec la commande MEM. L'accès aux lectures enregistrées se fait avec la commande RMEM ou en utilisant la "lecture implicite". La "lecture implicite" est exposée sous [Utilisation de la mémoire de lecture](#) au [chapitre 4](#).
- Si vous utilisez la mémoire de lecture pour des mesures sous-échantillonnées (commande SSAC ou SSDC), vous devez spécifier le format de mémoire SINT, le mode d'enregistrement FIFO (commande MEM FIFO) et la mémoire de lecture doit être vide (il suffit pour ce faire d'exécuter la commande MEM FIFO) avant que les échantillons ne soient pris. Si ces conditions ne sont pas satisfaites, le multimètre générera une erreur lorsque l'événement d'armement de déclenchement se produira.
- **Commande d'interrogation:** La commande d'interrogation MFORMAT? renvoie le format de mémoire couramment sélectionné. Pour plus de détails sur les [Commandes d'interrogation](#), se reporter au début du présent chapitre.
- **Commandes connexes:** MCOUNT?, MEM, MSIZE, RMEM

Exemple

```
10 OUTPUT 722;"NPLC 10"      !10 PLC DE TEMPS D'INTEGRATION
20 OUTPUT 722;"DCV 7"        !TENSION CONTINUE, GAMME 7 V
30 OUTPUT 722;"MATH OFF"     !SUPPRIME LES FONCTIONS MATH
40 OUTPUT 722;"MEM FIFO"     !VALIDE LA MEMOIRE DE LECTURE
45                            !(MODE FIFO)
```

```
50 OUTPUT 722;"MFORMAT DINT" !FORMAT MEMOIRE DINT
60 END
```

Quand vous rappelez des données enregistrées, assurez-vous que le 3458A est configuré comme il l'était lors de l'enregistrement.

MMATH

Memory math. La commande MMATH valide ou invalide les fonctions mathématiques en différé.

Syntaxe

```
MMATH [opération_a] [,opération_b]
```

opération Les choix possibles pour *opération* sont:

Paramètre événement	Équivalent numérique	Description
OFF	0	Invalide toutes les opérations mathématiques en temps réel préalablement validées.
CONT	1	Valide l'opération mathématique précédente. Pour revalider les deux opérations précédentes, envoyez MATH CONT,CONT.
CTHRM	3	Résultat = température (°C) d'une thermistance de 5 kΩ (40653B). La fonction doit être OHM ou OHMF (gamme 10 kΩ ou supérieure).
DB	4	Résultat = 20 x log ₁₀ (lecture/registre REF). Le registre REF est initialisé à 1, pour produire des dBV.
DBM	5	Résultat = 10 x log ₁₀ (lecture2/registre RES/1mW). La fonction doit être ACV, DCV ou ACDCV.
FILTER	6	Résultat = sortie du filtre passe-bas numérique pondérée exponentiellement. La réponse est donnée par le registre DEGREE.
FTHRM	8	Résultat = température (°F) d'une thermistance de 5 kΩ (40653B). La fonction doit être OHM ou OHMF (gamme 10 kΩ ou supérieure).

Paramètre événement	Équivalent numérique	Description
NULL	9	Résultat= lecture - registre OFFSET. Le registre OFFSET est initialement configuré par la première lecture - vous pouvez ensuite le modifier.
PERC	10	Résultat= ((lecture - registre PERC)/registre PERC) × 100.
PFAIL	11	Lecture comparée aux registres MAX et MIN
RMS	12	Résultat = lecture des carrés, s'applique à l'opération. FILTER, prend la racine carrée.
SCALE	13	Résultat= lecture - registre OFFSET)/registre SCALE.
STAT	14	Calcule des statistiques sur le jeu de lectures courant et sauvegarde les résultats dans les registres suivants: SDEV = écart-type MEAN = moyenne des lectures NSAMP = nombre de lectures UPPER= plus grande lecture LOWER = plus petite lecture
CTHRM2K	16	Résultat = température (°C) d'une thermistance de 2 kΩ (40653A). La fonction doit être OHM ou OHMF.
CTHRM10K	17	Résultat = température (°C) d'une thermistance de 10 kΩ (40653C). La fonction doit être OHM ou OHMF.
FTHRM2K	18	Résultat = température (°F) d'une thermistance de 2 kΩ (40653A). La fonction doit être OHM ou OHMF.
FTHRM10K	19	Résultat = température (°F) d'une thermistance de 10 kΩ (40653C). La fonction doit être OHM ou OHMLF.
CRTD85	20	Résultat = température (°C) d'un RTD de 100 Ω avec alpha de 0,00385 (40654A eu 40654B). La fonction doit être OHM ou OHMF.
CRTD92	21	Résultat= température (°C) d'un RTD de 100 Ω avec alpha de 0,003916. La fonction doit être OHM ou OHMF.

Paramètre événement	Équivalent numérique	Description
FRTD85	22	Résultat= température (°F) d'un RTD de 100 Ω avec alpha de 0,00385 (40654A ou 40654B). La fonction doit être OHM ou OHMF.
FRTD92	23	Résultat= température (°F) d'un RTD de 100 Ω avec alpha de 0,003916. La fonction doit être OHM ou OHMF.

Opération a, b à la mise sous tension= OFF,OFF
Opération a, b par défaut = OFF,OFF

Valeurs des registres à la mise sous tension = tous les registres sont mis à 0 avec les exceptions suivantes:

DEGREE = 20 REF = 1
SCALE = 1 RES = 50
PERC = 1

Points importants

- Lorsqu'elles sont validées, les opérations mathématiques en différé (exceptées STAT et PFAIL) s'effectuent sur chaque lecture au moment où elle est extraite ou copiée de la mémoire de lecture sur l'affichage ou dans la mémoire-tampon de sortie GPIB. (Les lectures en mémoire ne sont pas modifiées par une opération mathématique en différé). Les opérations STAT et PFAIL s'effectuent sur les lectures enregistrées en mémoire immédiatement après exécution de la commande MMATH. (Les opérations STAT et PFAIL ne sont pas mises à jour pour toute lecture supplémentaire placée en mémoire après exécution de la commande MMATH).
- Les résultats de l'opération STAT sont sauvegardés dans les registres mathématiques SDEV, MEAN, NSAMP, UPPER et LOWER (pour plus de détails sur ces registres, voir commande RMATH).
- A chaque fois que l'opération PFAIL détecte une lecture hors limite, le bit 1 du registre d'état est positionné (ceci met la ligne GPIB SRQ à l'état vrai si elle a été validée par la commande RQS) et le message FAILED LOW ou FAILED HIGH s'affiche.

- Une fois validée, une opération mathématique en différé reste active tant que vous n'invalides pas la fonction mathématique (MMATH OFF), que vous ne validez pas une opération mathématique en temps réel (commande MATH) ou que vous ne spécifiez pas d'autres opérations mathématiques en différé à l'aide de la commande MMATH (sauf comme décrit dans la remarque suivante).
- Lorsque la commande MMATH est exécutée à partir du panneau avant, le résultat est envoyé sur l'affichage uniquement. Lorsque la commande MMATH est exécutée à distance, le résultat est envoyé dans la mémoire tampon de sortie uniquement.
- Quand deux opérations mathématiques en temps réel sont validées, l'opération a est d'abord effectuée. Ensuite, l'opération b est effectuée sur le résultat de la première opération.
- Si une fonction mathématique en temps réel est validée, le 1/2 chiffre de l'affichage devient un chiffre entier. Ainsi, si vous effectuez des mesures de tension alternative avec 4 chiffres 1/2, puis que vous validez la fonction SCALE, l'affichage pourra montrer 5 chiffres entiers.
- Les registres mathématiques sont configurés avec la commande SMATH. Ils sont lus avec la commande RMATH.
- **Commande d'interrogation:** La commande d'interrogation MATH? renvoie deux réponses, séparées par une virgule, indiquant la (ou les) fonction(s) mathématique(s) en temps réel validée(s). Pour plus de détails sur les commandes d'interrogation, se reporter au début du présent chapitre.
- **Commandes connexes:** MATH, MEM, RMATH, RMEM, SMATH

Exemple

Le programme suivant effectue l'opération en différé NULL sur 20 lectures. Une fois la commande MMA TH N1JLL exécutée, 21 lectures sont effectuées et enregistrées en mémoire de lecture (mode FIFO). La ligne 80 rappelle la première lecture qui est stockée dans le registre OFFSET (décalage). La valeur du registre OFFSET (décalage) est ensuite modifiée à 3.05. Les 20 lectures restant en mémoire sont rappelées et l'opération NULL est effectuée sur chacune d'elles.

```

10 OPTION BASE 1           ! BORNE INFERIEURE DU TABLEAU A 1
20 DIM Rdgs(20)           ! DIMENSIONNE LE TABLEAU POUR 20 LECTURES
30 OUTPUT 722; "PRESET NORM" ! PRECONFIGURATION : NRDGS 1,AUTO, DCV 10
40 OUTPUT 722;"MEM FIFO"    ! VALIDE LA MEMOIRE DE LECTURE, MODE FIFO
50 OUTPUT 722;"MMATH NULL"  ! VALIDE LA FONCTION NULL EN DIFFERE
60 OUTPUT 722;"NRDGS 21"    ! 21 LECTURES PAR DECLENCHEMENT
70 OUTPUT 722;"TRIG SGL"    ! DECLENCHE LES LECTURES
80 ENTER 722;A              ! RAPPELLE LA PREMIERE LECTURE (LECTURE
85                          ! "IMPLICITE")
90 OUTPUT 722; "SMATH OFFSET, 3.05"! ECRIT 3,05 DANS LE
95                          ! REGISTRE DECALAGE
100 ENTER 722;Rdgs(*)       ! RAPPELLE LES LECTURES (LECTURE
105                          ! "IMPLICITE") ET EFFECTUE L'OPERATION
107                          ! NULL SUR CHACUNE D'ELLES
110 PRINT Rdgs(*)           ! IMPRIME LES LECTURES UNE FOIS CORRIGEEES
115                          ! PAR LA FONCTION NULL
120 END

```

MSIZE

Memory size. Sur les précédents multimètres Keysight, la commande MSIZE servait à effacer la mémoire et à allouer de l'espace mémoire pour les lectures, les sous-programmes et la sauvegarde des états. Le 3458A accepte la commande MSIZE pour des raisons de compatibilité de langage mais n'a aucun effet puisque les affectations de la mémoire du 3458A sont prédéfinies et ne peuvent pas être modifiées. La commande d'interrogation MSIZE? est cependant utilisée pour déterminer la mémoire de lecture totale et le plus grand bloc de mémoire de sous-programme/d'état inutilisé.

Syntaxe

MSIZE [*mémoire_lecture*][,*mémoire_sous-programme*]

Points importants

- Lorsqu'elle est utilisée, la mémoire de sous-programme/d'état est parfois fragmentée en de nombreux petits blocs. La commande MSIZE? renvoie le nombre total d'octets de mémoire de lecture et le nombre d'octets correspondant au plus grand bloc de mémoire de sous-programme/d'état inutilisé. La commande SCRATCH efface tous les sous-programmes et tous les états de la mémoire et les zones de mémoire qu'ils occupaient ne forment plus qu'un seul bloc contigu. De plus, lorsque le multimètre est mis hors/sous tension, il combine à chaque fois que possible les blocs de mémoire fragmentés.
- **Commande d'interrogation:** La commande d'interrogation MSIZE? renvoie deux réponses, séparées par une virgule. La première réponse correspond au nombre total d'octets de mémoire de lecture; la seconde réponse est le nombre d'octets correspondant au plus grand bloc de mémoire de sous-programme/d'état inutilisé.
- **Commandes connexes:** MCOUNT?, MEM, MFORMAT, RMEM, DELSUB, SCRATCH, SUB, SUBEND, SSTATE

Exemple

```
10 OUTPUT 722; "MSIZE?" !INTERROGE LES TAILLES MEMOIRE
20 ENTER 722;A,B       !ENTRE LES REPONSES DANS DES VARIABLES
30 PRINT A,B           !IMPRIME LES REPONSES
40 END
```

NDIG

Number of digits. La commande NDIG permet de spécifier le nombre de chiffres qu'affichera le multimètre.

Syntaxe

NDIG [*valeur*]

valeur Le paramètre valeur peut être un entier compris entre 3 et 8 (le multimètre dispose d' 1/2 chiffre implicite; si vous spécifiez NDIG 3 par exemple, le multimètre affichera 3,5 chiffres).

Valeur à la mise sous tension = 7 (7,5 chiffres)

Valeur par défaut = 7 (7,5 chiffres)

Points importants

- La commande NDIG définit le nombre maximal de chiffres à afficher. Elle n'affecte pas la résolution du convertisseur A/N ou les lectures envoyées sur le bus GPIB. Le multimètre ne peut afficher plus de chiffres que n'en résout le convertisseur A/N.
- La commande d'interrogation NDIG? renvoie le nombre de chiffres couramment spécifié. Pour plus de détails sur les
- **Commande d'interrogation:** La commande d'interrogation NDIG? renvoie le nombre de chiffres couramment spécifié. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** DISP

Exemple

```
10 OUTPUT 722; "RESET" !RETOUR A L'ETAT DE MISE SOUS
15                               !Tension
20 OUTPUT 722;"NDIG 8" !AFFICHE 8,5 CHIFFRES
30 END
```

NPLC

Number of power line cycles. La commande NPLC spécifie le temps d'intégration du convertisseur A/N en nombre de périodes secteur. Le temps d'intégration est le temps pendant lequel le convertisseur A/N mesure le signal d'entrée.

Syntaxe

NPLC [*nombre_périodes_secteur*]

nombre_périodes_secteur La commande NPLC sert avant-tout à définir la réjection de mode normal (NMR) à la fréquence de référence du convertisseur A/N (commande LFREQ). Toute valeur ≥ 1 pour le paramètre *nombre_périodes_secteur* fournit un NMR de 60 dB au moins à la fréquence secteur. Les valeurs < 1 ne

fournissent aucune réjection de mode normal; elles définissent simplement le temps d'intégration du convertisseur A/N. Les gammes et les valeurs d'incrémentations du paramètre *nombre_périodes_secteur* sont:

0 - 1 PLC par incréments de 0,000006 pour une fréquence de référence de 60 Hz (commande LFREQ)

OU

0 - 1 PLC par incréments de 0,000005 pour une fréquence de référence de 50 Hz

1 - 10 PLC par incréments de 1

10 - 1000 PLC par incréments de 10

Nombre_périodes_secteur à la mise sous tension = 10

Nombre_périodes_secteur par défaut = 0 (sélectionne le temps d'intégration minimal de 500 ns)

La relation entre le temps d'intégration (exprimé en PLC), la fréquence de référence du convertisseur A/N (commande LFREQ) et les chiffres de résolution est:

Chiffres de résolution			Périodes secteur (commande NPLC)	
DCV	DCI, OHM(F)	ACI, ACDCI, ACV ^[a] , ACDCV ^[a]	Fréquence de réf. (LFREQ) = 60 Hz	Fréquence de réf. (LFREQ) = 50 Hz
4,5	4,5	4,5	0 - 0,000030	0 - 0,000025
5,5	5,5	5,5	0,000036 - 0,000360	0,000030 - 0,000300
6,5	6,5	6,5	0,000366 - 0,030000	0,000305 - 0,025000
7,5	7,5 ^[b]	6,5	0,030006 - 1	0,025005 - 1
8,5 ^[b]	7,5 ^[b]	6,5	2 - 1000	2 - 1000

[a] Méthode de mesure analogique uniquement (commande SETACV ANA)

[b] Pour toutes les gammes exceptées la gamme 100 OHM(F) et la gamme DCV 100 mV. La gamme 100 OHM(F) a une résolution maximale de 6,5 chiffres et la gamme DCV 100 mV une résolution maximale de 7,5 chiffres.

Points importants

- Pour les fonctions de mesure ACV et ACDCV (méthode SETACV ANA uniquement), ACI, ACDCI, DCI, DCV, OHM et OHMF, la résolution est déterminée par le temps d'intégration du convertisseur A/N. Pour les mesures de tension alternative ou alternative + continue échantillonnées (méthode SETACV SYNC ou SETACV RNDM), le temps d'intégration est sélectionné automatiquement et la résolution spécifiée est obtenue en faisant varier le nombre d'échantillons. Pour les mesures numérisées (échantillonnage direct ou sous-échantillonnage), le temps d'intégration est fixe et ne peut être modifié.
- Comme les commandes NPLC et APER spécifient toutes deux le temps d'intégration, l'exécution de l'une de ces commandes annule automatiquement le temps d'intégration précédemment établi par l'autre. La commande RES ou le paramètre *%_résolution* d'une fonction ou de la commande RANGE peuvent également être utilisés pour sélectionner indirectement un temps d'intégration. Une interaction se produit alors avec la commande NPLC (ou APER) lorsque vous spécifiez la résolution que le multimètre résout comme suit:

Si vous envoyez la commande NPLC (ou APER) avant de spécifier la résolution, le multimètre satisfait la commande qui spécifie la plus grande résolution (plus grand temps d'intégration).

Si vous envoyez la commande NPLC (ou APER) après avoir spécifié la résolution, le multimètre utilise le temps d'intégration spécifié par la commande NPLC (ou APER) et ignore toute résolution spécifiée précédemment.
- L'approche la plus couramment utilisée est la première des deux mentionnées ci-dessus: la commande NPLC est exécutée d'abord pour établir la réjection de mode normal (NMR) puis le paramètre *%_résolution* est spécifié avec une fonction ou la commande RANGE. Ceci vous assure un NMR et au moins la résolution requise.
- **Commande d'interrogation:** La commande d'interrogation NPLC? retourne le temps d'intégration (en PLC - périodes secteur) utilisé par le convertisseur A/N. Comme ce temps peut avoir été spécifié par une commande APER, NPLC ou RES ou par le paramètre *%_résolution* d'une commande de fonction ou de la commande RANGE, le nombre de PLC renvoyé par la commande NPLC? peut être différent de celui qui avait été spécifié en dernier par la commande NPLC.

- **Commandes connexes:** APER, FUNC, LFREQ, RES

Exemples

Dans le programme suivant, la ligne 10 définit le nombre minimal de PLC et permet au paramètre *%_resolution* de la ligne 20 de contrôler la résolution. La résolution spécifiée par la ligne 20 est de 100 μV .

```
10 OUTPUT 722;"NPLC 0"           !DEFINIT LE NOMBRE DE PLC MAXIMUM
20 OUTPUT 722;"DCV 6,.00167" !VOLTS oc. 6V MAX. 100  $\mu\text{V}$  de RESOLUTION
30 END
```

Dans le programme suivant, la ligne 10 définit le nombre de PLC à 1000. Ceci correspond à la résolution maximale et empêche le paramètre *%_resolution* de la ligne 20 d'affecter la mesure. La résolution requise par la ligne 20 est de 10 m Ω mais du fait de la ligne 10, la résolution réelle est de 100 $\mu\Omega$.

```
10 OUTPUT 722;"NPLC 1000"       !DEFINIT LE NOMBRE DE PLC MAXIMUM
20 OUTPUT 722;"OHM 1E3,.001" !SELECTIONNE LES MESURES DE
25                               !RESISTANCE 2-FILS, ENTREE MAX 1 k $\Omega$ 
30 END
```

NRDGS

Number of readings. La commande NRDGS désigne le nombre de lectures effectuées par déclenchement et l'événement (d'échantillonnage) qui initialise chaque lecture.

Syntaxe

NRDGS [*nombre*][*événement*]

nombre Le paramètre nombre spécifie le nombre de lectures par déclenchement. La gamme de ce paramètre peut varier de 1 à 16777215 (le paramètre *nombre* correspond également au paramètre enregistrement de la commande RMEM; voir commande **RMEM** pour plus de détails à ce sujet).

Nombre à la mise sous tension = 1

Nombre par défaut = 1

événement Désigne l'événement qui initialise chaque lecture (événement d'échantillonnage). Les valeurs possibles de ce paramètre sont:

Paramètre événement	Équivalent numérique	Description
AUTO	1	Initialise une lecture à chaque fois que le multimètre est libre
EXTSYN	2	Initialise une lecture sur la transition négative sur le connecteur d'entrée externe du multimètre
SYN	5	Initialise une lecture lorsque la mémoire-tampon de sortie du multimètre est vide, que la mémoire de lecture est invalidée ou vide et que le contrôleur demande des données
TIMER ^[a]	6	Similaire à AUTO avec un intervalle de temps entre les lectures successives (spécifié à l'aide de la commande TIMER)
LEVEL ^[b]	7	Initialise une lecture lorsque le signal d'entrée atteint la tension spécifiée par la commande LEVEL sur la pente spécifiée par la commande SLOPE
LINE ^[a]	8	Initialise une lecture au passage de la tension secteur ca par zéro volt

[a] L'événement TIMER ou LINE ne peut pas être utilisé pour les mesures de tension alternative ou alternative + continue échantillonnées (SETACV RNDM ou SYNC) ni pour les périodes de fréquence ou de période.

[b] L'événement d'échantillonnage LEVEL ne peut être utilisé que pour les mesures de tension continue et en mode échantillonnage direct (numérisation).

Événement à la mise sous tension = AUTO

Événement par défaut= AUTO

Points importants

- L'événement TIMER désignant un intervalle entre les lectures, il ne s'applique que si le paramètre nombre est supérieur à 1. La première lecture se fait sans l'intervalle TIMER. Vous pouvez cependant insérer un intervalle de temps avant la première lecture à 1 l'aide de la commande DELAY. (L'événement TIMER suspend la fonction de changement de gamme automatique).
- Vous pouvez utiliser la commande SWEEP en remplacement des commandes NRDGS *n*, TIMER et TIMER *n*. La commande SWEEP spécifie le nombre de lectures et l'intervalle entre les lectures. Ces commandes sont interchangeable et le multimètre utilise celle qui a été exécutée en dernier. L'exécution de la commande SWEEP définit automatiquement l'événement

d'échantillonnage à TIMER. Dans les états de mise sous tension, RESET et PRESET, le multimètre utilise la commande NRDGS.

- Lorsque SYN est utilisé pour plusieurs événements d'armement, de déclenchement ou d'échantillonnage, la première occurrence de l'événement SYN satisfait tous les événements SYN spécifiés, comme l'illustre le second "exemple SYN" ci-dessous.
- **Commande d'interrogation:** La commande d'interrogation NRDGS? renvoie deux réponses, séparées par une virgule. La première réponse est le nombre de lectures spécifié; la seconde réponse est l'événement d'échantillonnage courant. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** DELAY, LEVEL, RMEM, SLOPE, TARM, TIMER, TRIG, SWEEP

Exemples

Événement SYN

Dans le programme suivant, la ligne 70 demande des données au multimètre. Ceci satisfait l'événement SYN et initialise une lecture. La lecture est ensuite envoyée au contrôleur et imprimée. Le processus se répète jusqu'à ce que les 3 lectures spécifiées aient été effectuées et imprimées.

10 OPTION BASE 1	! LIMITE INFERIEURE DU TABLEAU A 1
20 DIM A(3)	! DIMENSIONNE LE TABLEAU
30 OUTPUT 722;"DCV 8,.00125"	! MESURE DE TENSION CONTINUE,
35	! GAMME 10 V, RESOLUTION 100 µV
40 OUTPUT 722;"NRDGS 3, SYN"	! 3 LECTURES/DECLenchement,
45	! EVENEMENT D'ECHANTILLONNAGE SYN
50 OUTPUT 722;"TRIG AUTO"	! DECLenchement AUTOMATIQUE
60 ENTER 722;A(*)	! ENTRE LES LECTURES
70 PRINT A(*)	! IMPRIME LES LECTURES
80 END	

Dans l'exemple suivant, les événements d'armement, de déclenchement et d'échantillonnage sont définis en mode TIMER. Cinq lectures par déclenchement sont spécifiées. Dès qu'un événement SYN se produit (ligne 60), il satisfait l'événement d'armement, de déclenchement et le premier événement

d'échantillonnage, ce qui initialise la première lecture. Quatre autres événements SYN (un par lecture) sont alors requis pour initialiser les quatre lectures restantes.

```

10 OPTION BASE 1                ! LIMITE INFERIEURE DU TABLEAU A 1
20 DIM Rdgs(5)                  ! DIMENSIONNE LE TABLEAU POUR LES
25                               ! LECTURES
30 OUTPUT 722;"PRESET NORM"      ! DECLENCHEXENT SYN, MESURE DE
35                               ! TENSION CONTINUE, NPLC 1, MEMOIRE INVALIDEE
40 OUTPUT 722;"TARM SYN"         ! ARMEMENT DE DECLENCHEMENT SYN
50 OUTPUT 722;"NRDGS 5, SYN"     ! 5 LECTURES/DECLENCHEMENT,
55                               ! EVENEMENT D'ECHANTILLONNAGE SYN
60 ENTER 722;Rdgs(*)            ! EVENEMENT SYN, ENTRE LES
70 PRINT Rdgs(*)                ! IMPRIME LES LECTURES
80 END

```

TIMER

Lorsque vous exécutez le programme suivant, le multimètre effectue 4 lectures en réponse à un déclenchement unique. La première lecture est immédiate; les 3 suivantes interviennent à des intervalles de 10 ms.

```

10 OPTION BASE 1                ! LIMITE INFERIEURE DU TABLEAU A 1
20 DIM Rdgs(4)                  ! DIMENSIONNE LE TABLEAU POUR LES
25                               ! LECTURES
30 OUTPUT 722;"PRESET FAST"      ! ARMEMENT DE DECLENCHEMENT
35                               ! NPLC 1, LECTURES RAPIDES
40 OUTPUT 722;"DCV 10"          ! MESURE DE TENSION CONTINUE,
50 OUTPUT 722;"TIMER 10E-3"     ! DEFINIT L'INTERVALLE ENTRE
55                               ! LES LECTURES A 10 ms
60 OUTPUT 722;"NRDGS 4,TIMER"    ! SELECTIONNE 4 LECTURES/-
65                               ! DECLENCHEMENT & TIMER
70 OUTPUT 722;"•TJIRM SGL"      ! DECLENCHEMENT UNIQUE
80 ENTER 722;Rdgs(*)            ! ENTRE LES LECTURES
90 PRINT Rdgs(*)                ! IMPRIME LES LECTURES
100 END

```

OCOMP

La commande OCOMP (offset compensation - compensation de décalage) valide ou invalide la fonction de compensation de décalage de résistance.

Syntaxe

OCOMP [*contrôle*]

contrôle Les valeurs possibles du paramètre *contrôle* sont:

Paramètre <i>contrôle</i>	Équivalent numérique	Description
OFF	0	Compensation de décalage de résistance invalidée.
ON	1	Compensation de décalage de résistance validée.

Contrôle à la mise sous tension = OFF.

Contrôle par défaut = ON.

Points importants

- Si la compensation de décalage est validée, le 3458A mesure la tension de décalage externe (avec source des courant de résistance invalidée) avant chaque lecture de résistance et la soustrait de la lecture suivante. Ceci empêche la tension de décalage d'affecter la lecture de résistance mais double le temps nécessaire par lecture.
- Vous pouvez utiliser la fonction de compensation de décalage pour les mesures de résistance 2- et 4-fils. Si la compensation de décalage est validée et que vous passez d'une mesure de résistance à une autre fonction de mesure (DCV, ACV, etc), la compensation de décalage est temporairement invalidée. Cependant, si vous revenez aux mesures de résistances 2- ou 4-fils, la compensation de décalage est de nouveau active.
- Le 3458A n'effectue une compensation de décalage que sur les gammes 10 Ω à 100 k Ω . Si OCOMP est validé pour une autre gamme, la mesure est effectuée sans compensation.

- **Commande d’interrogation:** La commande d’interrogation OCOMP? renvoie le mode de compensation de décalage courant Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** OHM, OHMF

Exemple

```
OUTPUT 722;"OCOMP ON" !VALIDE LA COMPENSATION DE DECALAGE
```

OFORMAT

Output format. La commande OFORMAT permet de spécifier le format de sortie des lectures directement envoyées au contrôleur ou transférées de la mémoire de lecture au contrôleur.

Syntaxe

```
OFORMAT [format]
```

format Les valeurs possibles du paramètre *format* sont:

Paramètre <i>format</i>	Équivalent numérique	Descriptions
ASCII	1	ASCII - 15 octets par lecture (voir points 1 et 2 ci-dessus)
SINT	2	Entier simple - 16 bits en complément à 2 (2 octets par lecture)
DINT	3	Entier long - 32 bits en complément à 2 (4 octets par lecture)
SREAL	4	Réel simple - (IEEE-754) 32 bits (4 octets par lecture)
DREAL	5	Réel long - (IEEE-754) 64 bits, (8 octets par lecture)

Format à la mise sous tension = ASCII

Format par défaut = ASCII

Points importants

- Le format de sortie ASCII envoie un cr lf (retour chariot, saut de ligne) pour indiquer la fin de la transmission à la plupart des ordinateurs. Les formats de sortie SINT, DINT, SREAL, DREAL, cependant, n'envoient pas de cr lf. Avec ces

formats, vous pouvez utiliser la commande END pour indiquer la fin de la transmission en utilisant la fonction EOI (GPIB). Pour plus de détails à ce sujet, voir commande **END**.

- Avec le format ASCII, deux octets supplémentaires sont requis pour la séquence *cr lf*. Cette séquence de fin de ligne n'est utilisée que par le format ASOI et termine normalement chaque lecture envoyée au format ASCII. Toutefois, si vous utilisez le format de sortie ASCII et que vous rappelez plusieurs lectures de la mémoire de lecture à l'aide de la commande RMEM, le multimètre place une virgule entre les lectures (virgule = 1 octet). Dans ce cas, la séquence *cr lf* n'apparaît qu'une seule fois, à la fin de la dernière lecture du groupe rappelé. Les virgules ne sont pas utilisées lorsque les lectures sont directement envoyées au bus (mémoire de lecture invalidée); lorsque les lectures sont rappelées "implicitement" ou si vous utilisez un format de sortie autre que ASCII.
- Le multimètre signale une condition de surcharge (entrée trop importante pour la gamme) en affichant le plus grand nombre possible pour le format de sortie spécifié, à savoir:
 Format SINT = +32767 ou -32768 (sans facteur d'échelle)
 Format DINT = +2.147483647E+9 ou -2.147483648E+9 (sans facteur d'échelle)
 Formats ASCII, SREAL, DREAL = +/- 1.0E+38
- Lorsque la mémoire de lecture est invalidée, l'exécution de la commande SSAC ou SSDC (sous-échantillonnage) définit automatiquement le format de sortie à SINT, quel qu'ait été le format de sortie précédemment spécifié. Pour un sous-échantillonnage, vous devez impérativement utiliser le format de sortie SINT si vous n'utilisez pas la mémoire de lecture.
- Le format de sortie ne s'applique qu'aux lectures transférées sur le bus GPIB. Les réponses aux commandes d'interrogation sont toujours envoyées au format ASCII, quelque soit le format de sortie spécifié. Après la réponse à l'interrogation, le format de sortie revient au type spécifié précédemment. Le format de sortie n'affecte pas le format de mémoire spécifié par la commande MFORMAT.
- Avec les formats de sortie SINT ou DINT, le multimètre applique un facteur d'échelle pour chaque lecture. Ce facteur dépend de la fonction de mesure, de la gamme, de la configuration du convertisseur A/N et des opérations mathématiques validées. Par conséquent, avant d'interroger le facteur d'échelle (commande ISCALE?), assurez-vous que le multimètre est configuré comme il l'était pendant les mesures.

- Il n'est pas conseillé d'utiliser le format de sortie ou de mémoire SINT ou DINT pour les mesures de fréquence ou de période. lorsqu'une opération mathématique en temps réel ou différé est validée (sauf STAT ou PFAIL) ou encore lorsque la fonction de changement de gamme automatique est validée.
- **Commande d'interrogation:** La commande d'interrogation OFORMAT? renvoie le format de sortie courant Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** END, ISCALE?, MFORMAT, QFORMAT

Exemples

Format SINT

Le programme suivant envoie 10 lectures au format SINT, interroge le facteur d'échelle et multiplie ce facteur par chaque lecture.

```

10 OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Num_readings          ! DECLARATION DE LA VARIABLE
30 INTEGER Int_rdgs (1:10) BUFFER ! CREATION DU TABLEAU DES ENTIERS
35                               ! EN MEMOIRE-TAMPON
40 REAL Rdgs(1:10)               ! CREATION DU TABLEAU DES REELS
50 Num_readings=10               ! NOMBRE DE LECTURES= 10
60 ASSIGN @Dvm TO 722            ! AFFECTATION DE L'ADRESSE DU MULTIMETRE
70 ASSIGN @Int_rdgs TO BUFFER Int_rdgs(*) ! AFFECTATION DU NOM
75                               ! D'ACCES DE LA MEMOIRE-TAMPON
80 OUTPUT @Dvm;"PRESET NORM;OFORMAT SINT;NPLC 0;NRDGS ";Num_readings
85   ! TARM AUTO, TRIG SYN, FORMAT DE SORTIE SINT, TEMPS
87   ! D'INTEGRATION MIN.
90 TRANSFER @Dvm TO @Int_rdgs;WAIT ! EVENEMENT SYN, TRANSFERT DES
92   ! LECTURES DANS LE-TABLEAU CES ENTIERS; PAS DE CONVERSION DE
95   ! DONNEES REQUISES PUISQUE LE FORMAT INTEGER DE L'ORDINATEUR EST
97   ! IDENTIQUE A SINT (MAIS TABLEAUX DES ENTIERS REQUIS)
100 OUTPUT @Dvm;"ISCALE?"        ! INTERROGATION DU FACTEUR D'ECHELLE POUR
102                               ! LE FORMAT SINT
110 ENTER @Dvm;S                 ! LECTURE DU FACTEUR D'ECHELLE
120 FOR I=1 TO Num_readings
130 Rdgs(I)=Int_rdgs(I)          ! CONVERSION DE CHAQUE LECTURE DU FORMAT
135   ! ENTIER AU FORMAT REEL(OBLIGATOIRE POUR EVITER UN

```

```

138      ! DEPASSEMENT ENTIER SUR LA LIGNE SUIVANTE)
140 R=ABS(Rdgs(I))          ! UTILISATION DE LA VALEUR ABSOLUE POUR
142                        ! VERIFIER SURCHARGE
150 IF R>=32767 THEN PRINT "OVL" ! SI SURCHARGE, IMPRESSION D'UN
152                        ! MESSAGE
160 Rdgs(I)=Rdgs(I)*S      ! MULTIPLICATION DE LA LECTURE PAR LE
162                        ! FACTEUR D'ECHELLE
170 Rdgs(I)=DROUND(Rdgs(I),4) ! VALEUR ARRONDIE A 4 CHIFFRES
180 NEXT I
190 END

```

Format DINT

L'exemple suivant est identique au précédent à part qu'il effectue 50 lectures en place de 10 et les transmet à l'ordinateur en utilisant le format DINT.

```

10 OPTION BASE 1          ! BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Num_readings,I,J,K ! DECLARATION DES VARIABLES
30 Num_readings=50        ! NOMBRE DE LECTURES = 50
40 ALLOCATE REAL Rdgs(1:Num_readings) ! CREATION D'UN TABLEAU POUR
42                        ! LES LECTURES
50 ASSIGN @Dvm TO 722      ! AFFECTATION DE L'ADRESSE DU MULTIMETRE
60 ASSIGN dBuffer TO BUFFER[4*Num_readings] ! AFFECTATION DU NOM
65                        ! D'ACCES DE LA MEMOIRE-TAMPON
70 OUTPUT @Dvm;"PRESET NORM;RANGE 10;OFORMAT DINT;NRDGS";Num_readings
75      ! TARM AUTO, TRIG SYN, DCV GAMME 10 V, FORMAT DE SORTIE DINT,
77      ! 50 LECTURES,AUTO
80 TRANSFER @Dvm TO @Buffer;WAIT ! EVENEMENT SYN, TRANSFERT DES
82                        ! LECTURES
90 OUTPUT @Dvm; "ISCALE?"    ! INTERROGATION DU FACTEUR D'ECHELLE POUR
92                        ! LE FORMAT DINT
100 ENTER @Dvm; S           ! LECTURE DU FACTEUR D'ECHELLE
110 FOR I=1 TO Num_readings
120 ENTER @Buffer USING "#,W,W";J,K ! METTRE UN MOT DE 16 OCTETS
122      ! NOTATION COMPLEMENT A 2 DANS CHAQUE VARIABLE J ET K {# = FIN
125      ! D'INSTRUCTION NON REQUISE; W = METTRE DONNEES SOUS FORME
127      ! ENTIER 16 BITS NOTATION COMPLEMENT A 2)

```



```
130 Rdgs(I)=(J*65536.+K+65536.*(K<0))! CONVERTIR EN NB REEL
140 R=ABS(Rdgs(I))          ! UTILISATION DE LA VALEUR ABSOLUE POUR
142                          ! VERIFIER SURCHARGE
150 IF R>2147483647 THEN PRINT "OVLD" ! SI SURCHARGE, IMPRESSION
152                          ! D'UN MESSAGE
160 Rdgs(I)=Rdgs(I)*S        ! APPLICATION DU FACTEUR D'ECHELLE
170 Rdgs(I)=DROUND(Rdgs(I),8) ! ARRONDIT LECTURE CONVERTIE
180 PRINT Rdgs(I)           ! IMPRESSION DES LECTURES
190 NEXT I
200 END
```

Format SREAL

Le programme suivant montre comment convertir 10 lectures au format SREAL.

```

10 OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Num_readings         ! DECLARATION DE LA VARIABLE
30 Num_readings=10              ! NOMBRE DE LECTURES = 10
40 ALLOCATE REAL Rdgs(1:Num_readings) ! CREATION D'UN TABLEAU POUR
42                               ! LES LECTURES
50 ASSIGN @Dvm TO 722           ! AFFECTATION DE L'ADRESSE DU MULTIMETRE
60 ASSIGN @Buffer TO BUFFER [4*Num_readings] ! AFFECTATION DU NOM
65                               ! D'ACCES DE LA MEMOIRE-TAMPON
70 OUTPUT @Dvm;"PRESET NORM;OFORMAT SREAL;NRDGS";Num_readings
75 ! TRIG SYN, FORMAT DE SORTIE SREAL, 1 PLC, DCV GAMME AUTO,
77                               ! 10 LECTURES
80 TRANSFER @Dvm TO @Buffer;WAIT ! EVENEMENT SYN, TRANSFERT DES
82                               ! LECTURES
90 FOR I=1 TO Num_readings
100 ENTER @Buffer USING "#,B";A,B,C,D ! METTRE UN OCTET DE 8 BITS
102 ! DANS CHAQUE VARIABLE, (1i= FIN D'INSTRUCTION NON REQUISE; B
105 ! = LIRE UN OCTET DE 8 BITS ET L'INTERPRETER COMME UN ENTIER
107 ! ENTRE 0 ET 255)
110 S=1                          ! CONVERTIT LECTURE A PARTIR DE SREAL
120 IF A>127 THEN S=-1           ! CONVERTIT LECTURE A PARTIR DE SREAL
130 IF A>127 THEN A=A-128        ! CONVERTIT LECTURE A PARTIR DE SREAL
140 A=A*2- 127                   ! CONVERTIT LECTURE A PARTIR DE SREAL
150 IF B>127 THEN A=A+1         ! CONVERTIT LECTURE A PARTIR DE SREAL
160 IF B<=127 THEN B=B+128      ! CONVERTIT LECTURE A PARTIR DE SREAL
170 Rdgs(I)=S*(B*65536.+C*256.+D)*2^(A-23) ! CONVERTIT LECTURE A
175                               ! PARTIR DE SREAL
180                               ! ARRONDIT LA LECTURE A 7
182 ! CHIFFRES; OBLIGATOIRE AVEC SREAL POUR S'ASSURER QUE LES
185 ! VALEURS DE SURCHARGE SERONT ARRONDIES A 1 .E+38 (SANS
187 ! ARRONDI, LA VALEUR PEUT ETRE LEGEREMENT INFERIEURE)
190 IF ABS(Rdgs(I))=1.E+38 THEN ! EN CAS DE SURCHARGE :
200 PRINT "Overload Occurred" ! IMPRIME " SURCHARGE"
210 ELSE                         ! SI PAS DE SURCHARGE :
220 PRINT Rdgs(I)               ! IMPRIME LES LECTURES

```

```

230 END IF
240 NEXT I
250 END

```

Format DREAL

Le programme suivant utilise le format de sortie DREAL. Vous remarquerez qu'aucune conversion n'est nécessaire avec ce format qui utilise la même représentation de données que le contrôleur (8 octets/mot).

```

10 OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A 1
20 REAL Rdgs(1:10) BUFFER      ! CREATION DU TABLEAU DES REELS EN
25                               ! EN MEMOIRE-TAMPON
30 ASSIGN @Dvm TO 722          ! AFFECTATION DE L'ADRESSE DU MULTIMETRE
40 ASSIGN @Rdgs TO BUFFER Rdgs(*) ! AFFECTATION DU NOM D'ACCES DE
45                               ! LA MEMOIRE-TAMPON
50 OUTPUT @Dvm;"PRESET NORM;NPLC 10;OFORMAT DREAL;NRDGS 10"
55 ! TRIG SYN, 10 PLC, DCV GAMME AUTO,FORMAT DE SORTIE DREAL, 10
57 ! LECTURES/DECLenchement
60 TRANSFER @Dvm TO @Rdgs;WAIT ! EVENEMENT SYN, TRANSFERT DES
65                               ! LECTURES
70 FOR I=1 TO 10
80 IF ABS(Rdgs(I))=1.E+38 THEN ! EN CAS DE SURCHARGE :
90 PRINT "OVERLOAD OCCURRED" ! IMPRIME "SURCHARGE"
100 ELSE                       ! SI PAS DE SURCHARGE :
110 Rdgs(I)=DROUND(Rdgs(I),8) ! ARRONDIT LES MESURES
120 PRINT Rdgs(I)             ! IMPRIME LES LECTURES
130 END IF
140 NEXT I
150 END

```

Le programme précédent utilise l'instruction TRANSFER pour extraire les lectures du multimètre. Le programme suivant utilise l'instruction ENTER pour transférer les lectures sur l'ordinateur en utilisant le format DREAL. L'instruction ENTER est plus simple d'emploi puisqu'elle ne requiert aucun nom d'accès mais elle est plus lente que l'instruction TRANSFER. En outre, avec l'instruction ENTER vous devez

utiliser la commande FORMAT OFF pour que le contrôleur utilise sa structure de données interne au lieu du format ASCII.

```

10 OPTION BASE 1                ! BORNE INFERIEURE DU TABLEAU A 1
20 Num_readings=20              ! NOMBRE DE LECTURES = 20
30 ALLOCATE REAL Rdgs(1:Num_readings) ! CREATION D'UN TABLEAU POUR
32                               ! LES LECTURES
40 ASSIGN @Dvm TO 722           ! AFFECTATION DE L'ADRESSE DU MULTIMETRE
50 OUTPUT @Dvm;"PRESET NORM;OFORMAT DREAL;NPLC 10;NRDGS";Num_readings
55   ! TRIG SYN, DCV Gamme auto, FORMAT DE SORTIE DREAL, 10 PLC, 20
57   ! LECTURES/DECLenchement
60 ASSIGN @Dvm;FORMAT OFF       ! STRUCTURE DE DONNEES = 8 OCTETS/MOT
70 FOR I=1 TO Num_readings
80 ENTER @Dvm;Rdgs(I)           ! TRANSFERER CHAQUE LECTURE
90 IF ABS(Rdgs(I))=1.E+38 THEN ! EN CAS DE SURCHARGE
100 PRINT "OVERLOAD OCCURRED"   ! IMPRIME "SURCHARGE"
110 ELSE                         ! SI PAS DE SURCHARGE
120 Rdgs(I)=DROUND(Rdgs(I),8)   ! ARRONDIT LES MESURES A 8
125                               ! CHIFFRES
130 PRINT Rdgs(I)               ! IMPRIME LES LECTURES
140 END IF
150 NEXT I
160 END

```

OHM, OHMF

Voir commande **FUNC**.

OPT?

Option query. La commande d'interrogation OPT? renvoie une réponse indiquant les options installées dans le multimètre. Les réponses possibles sont:

0 = Aucune option installée
 1 = Extended Reading Memory Option

Syntaxe

OPT?

Points importants

- **Commandes connexes:** QFORMAT

Exemple

```
10 OUTPUT 722;"OPT?" !DEMANDE LES OPTIONS
15                      !INSTALLEES
20 ENTER 722;A$       !ENTRE LA REPONSE
30 PRINT A$           !IMPRIME LA REPONSE
40 END
```

PAUSE

La commande PAUSE suspend l'exécution d'un sous-programme. L'exécution reprend dès que vous envoyez une commande CONT ou à réception d'un GET (Group Execute Trigger- Déclenchement d'exécution de groupe) GPIB.

Syntaxe

PAUSE

Points importants

- La commande PAUSE n'est autorisée que dans un sous-programme.
- Un seul sous-programme peut être suspendu à la fois. Si un sous-programme est suspendu alors qu'un autre s'exécute et est suspendu à son tour, le premier terminera de s'exécuter et le second restera suspendu.
- Lorsque la mémoire-tampon d'entrée est invalidée (commande INBUF OFF), le multimètre conserve normalement le bus jusqu'à ce que le sous-programme appelé ait terminé de s'exécuter. Si le sous-programme comporte une instruction PAUSE, le bus est immédiatement libéré.
- Les commandes PAUSE emboîtées ne sont pas autorisées; en d'autres termes, lorsqu'un sous-programme est appelé par un autre sous-programme, le sous-programme appelé ne peut pas contenir de commande PAUSE.
- **Commande d'interrogation:** La commande d'interrogation PAUSE? renvoie une réponse indiquant si un sous-programme est actuellement suspendu ou non. Les réponses possibles sont YES (équivalent numérique = 1): un sous-programme est suspendu; ou NO (équivalent numérique= 0).

- **Commandes connexes:** CALL, COMPRESS, CONT, DELSUB, TRIGGER (commande GPIB), SCRATCH, SUB, SUBEND

Exemple

```

10 OUTPUT 722;"SUB OHMAC1"      !SAUVEGARDE LE SOUS-PROGRAMME
15                               !INTITULE OHMAC1
20 OUTPUT 722;"PRESET NORM"     !SUSPEND LE DECLenchement,
25                               !PRECONFIGURATION
30 OUTPUT 722;"MEM FIFO"        !VALIDE LA MEMOIRE DE LECTURE, MODE FIFO
40 OUTPUT 722;"OHM"             !SELECTIONNE LES MESURES DE
45                               !RESISTANCE 2-FILS
50 OUTPUT 722;"NRDGS 5"         !SELECTIONNE 5 LECTURES/DECLenchement
60 OUTPUT 722;"TRIG SGL"        !GENERE UN DECLenchement UNIQUE
70 OUTPUT 722;"PAUSE"           !SUSPEND L'EXECUTION DU PROGRAMME
80 OUTPUT 722;"ACV"             !SELECTIONNE LES MESURES DE TENSION
85                               !ALTERNATIVE
90 OUTPUT 722;"NRDGS 10"        !SELECTIONNE 10 LECTURES/DECLenchement
100 OUTPUT 722;"TRIG SGL"        !GENERE UN DECLenchement UNIQUE
110 OUTPUT 722;"SUBEND"         !MARQUE LA FIN DU SOUS-PROGRAMME
120 END

```

Lorsque vous appelez le sous-programme ci-dessus, le multimètre l'exécute ligne par ligne. Les lignes 20 à 60 demandent au multimètre d'effectuer 5 lectures de résistance 2-fils et de les placer en mémoire de lecture. La ligne 70 interrompt l'exécution du sous-programme. Seule une commande CONT ou un Déclenchement par groupe GPIB (commande GET) lui permettra de poursuivre son exécution. Les lignes 80 à 100 demandent alors au multimètre d'effectuer 10 lectures de tension alternative et de les placer en mémoire de lecture. Quand le sous-programme est terminé, 15 lectures sont en mémoire. Pour appeler le sous-programme ci-dessus, envoyez:

```
OUTPUT 722;"CALL OHMAC1"
```

Quand les mesures de résistance 2-fils sont terminées, connectez une source de tension alternative au multimètre et reprenez l'exécution du sous-programme en envoyant la commande CONT ou en exécutant (sur le contrôleur):

```
TRIGGER 7
```

PER

Period. La commande PER demande au multimètre de mesurer la période du signal d'entrée. Vous devez spécifier si le signal d'entrée est une tension alternative (valeur par défaut), une tension alternative + continue, un courant alternatif, ou un courant alternatif+ continu à l'aide de la commande FSOURCE.

Syntaxe

PER [entrée_max][, %_resolution]

entrée_max Sélectionne une gamme fixe ou le mode gamme automatique. Les gammes correspondent au type de signal d'entrée spécifié dans la commande FSOURCE. Si par exemple le signal d'entrée est une tension alternative, le paramètre *entrée_max* spécifie une gamme de tensions alternatives. Pour sélectionner une gamme fixe, spécifiez l'*entrée_max* comme la valeur absolue (pas de valeurs négatives) de la valeur crête attendue du signal d'entrée. Voir commande **FUNC** ou **RANGE** pour connaître les gammes disponibles pour chaque type de signal d'entrée.

Pour sélectionner le mode de gamme automatique, spécifiez AUTO ou le paramètre par défaut pour *Entrée_max*. Dans le mode de gamme automatique, le multimètre échantillonne le signal d'entrée avant chaque mesure et sélectionne la gamme appropriée.

Entrée_max à la mise sous tension = non applicable
Entrée_max par défaut= AUTO

%_resolution Le paramètre *%_resolution* spécifie le nombre de chiffres de résolution et le temps de porte, comme illustré ci-dessous (*%_resolution* affecte également la vitesse de lecture; voir **“Annexe A : Spécifications”** à la page 411 pour plus de détails).

Paramètre %_resolution	Sélectionne le temps de porte	Résolution (en nombre de chiffres)
0,00001	1 s	7
0,0001	100 ms	7
0,001	10 ms	6
0,01	1 ms	5
0,1	100 µs	4

%_resolution à la mise sous tension = non applicable

%_resolution par défaut = 0,00001

Points importants

- La vitesse de lecture correspond à 1 période du signal d'entrée. au temps de porte ou à la temporisation de lecture par défaut de 1.2 secondes (valeur la plus grande des trois).
- Les mesures de période (et de fréquence) utilisent les circuits de détection de niveau pour déterminer quand le signal d'entrée passe par une tension particulière sur sa pente positive ou négative. (C'est la raison pour laquelle vous ne pouvez pas utiliser l'événement de déclenchement ou d'échantillonnage LEVEL ou l'événement de déclenchement LINE lorsque vous mesurez des périodes ou des fréquences). La valeur de déclenchement par niveau à la mise sous tension ou par défaut sélectionne 0 volt, pente positive. Vous pouvez modifier la tension de déclenchement à l'aide de la commande LEVEL et la pente (positive ou négative) à l'aide de la commande SLOPE.
- Le chiffre de poids fort (qui est un 1/l chiffre pour la plupart des fonctions de mesure) est un chiffre entier (0-9) pour les mesures de période.
- Les lectures avec la gamme automatique validée sont plus longues car le signal d'entrée est échantillonné (pour déterminer la gamme adéquate) entre chaque lecture.
- Pour les mesures de période (et de fréquence), une indication de surcharge signifie que l'amplitude de la tension ou du courant est trop forte pour la gamme spécifiée. Cela ne signifie pas que la période (ou la fréquence) appliquée est trop grande pour être mesurée.
- **Commandes connexes:** ACBAND, FREQ, FSOURCE, FUNC, RES

Exemple

```
10 OUTPUT 722;"FSOURCE ACI" !SELECTIONNE LE COURANT ALTERNATIF COMME
15                               !SOURCE D'ENTREE
20 OUTPUT 722;"PER .01"       !SELECTIONNE LES MESURES DE PERIODE,
25                               !GAMME 10 mA
30 END
```


PRESET

La commande PRESET configure le multimètre à un de ses trois états prédéfinis.

Syntaxe

PRESET [*type*]

type Spécifie l'état de préconfiguration NORM, FAST ou DIG (les équivalents numériques de ces paramètres sont 1, 0 et 2 respectivement).

Type à la mise sous tension = non applicable

Type par défaut = NORM

NORM PRESET NORM est similaire à RESET mais optimise le multimètre pour une commande à distance. Exécuter PRESET NORM revient à exécuter les commandes suivantes:

```
ACBAND 20,2E+6    MEM OFF (dernière opération mémoire définie à FIFO)
AZERO ON          MFORMAT SREAL
BEEP ON           MMATH OFF
DCV AUTO          NDIG 6
DELAY -1          NPLC 1
DISP ON           NRDGS 1,AUTO
FIXEDZ OFF        OCOMP OFF
FSOURCE ACV       OFORMAT ASCII
INBUF OFF         TARM AUTO
LOCK OFF          TIMER 1
MATH OFF          TRIG SYN
Tous les registres mathématiques sont à 0 exceptés
DEGREE = 20
PERC = 1
REF = 1
RES = 50
SCALE = 1
```

FAST PRESET FAST configure le multimètre pour des mesures rapides, un transfert rapide en mémoire et un transfert rapide de la mémoire au bus GPIB. (Pour plus de détails sur les mesures rapides, se reporter à [Augmentation de la](#)

vitesse de lecture dans le chapitre 4). Exécuter PRESET FAST revient à exécuter les commandes de PRESET NORM aux exceptions suivantes près in:

```
DCV 10
AZERO OFF
DISP OFF
MFORMAT DINT
OFORMAT DINT
TARM SYN
TRIG AUTO
```

DIG PRESET DIG configure le multimètre pour la numérisation de tension continue (pour plus de détails à ce sujet. se reporter au chapitre 5). Exécuter PRESET DIG revient à exécuter les commandes de PRESET NORM aux exceptions suivantes près:

```
DCV 10
AZERO OFF
DELAY 0
DISP OFF
TARM HOLD
TRIG LEVEL
LEVEL 0,AC
NRDGS 256,TIMER
TIMER 20E-6
APER 3E-6
MFORMAT SINT
OFORMAT SINT
```

Points importants

- **Commandes connexes:** RESET

Exemples

```
OUTPUT 722;"PRESET NORM" !PRECONFIGURE LE MULTIMETRE POUR UN
!FONCTIONNEMENT A DISTANCE
OUTPUT 722;"PRESET FAST" !PRECONFIGURE LE MULTIMETRE POUR DES
!LECTURES/TRANSFERTS RAPIDES
OUTPUT 722;"PRESET DIG" !PRECONFIGURE LE MULTIMETRE POUR LA
!NUMERISATION DE TENSION CONTINUE RAPIDE
```

PURGE

Purge state. La commande PURGE supprime l'état spécifié de la mémoire.

Syntaxe

PURGE *nom*

nom Nom de l'état. Un nom d'état peut comporter jusqu'à 10 caractères alphabétiques, alphanumériques ou être un entier compris entre 0 et 127. Pour plus de détails à ce sujet. voir commande **SSTATE**.

Nom à la mise sous tension= aucun

Nom par défaut= aucun; paramètre obligatoire

Points importants

- Pour supprimer tous les états enregistrés en mémoire. utilisez la commande SCRATCH.
- **Commandes connexes:** DELSUB, SCRATCH

Exemple

```
OUTPUT 722; "PURGE A2"!SUPPRIME L'ETAT A2 DE LA MEMOIRE
```

QFORMAT

Query format. La commande QFORMAT spécifie si les réponses aux interrogations contiennent des caractères numériques ou alphabétiques (autant que possible) et si les en-têtes de commande sont renvoyés ou pas.

Syntaxe

QFORMAT [*type*]

type Les valeurs possibles pour le paramètre type sont:

Paramètre <i>type</i>	Équivalent numérique	Description
NUM	0	Les réponses aux interrogations envoyées sur le bus GPIB ou sur l'affichage sont uniquement numériques (autant que possible), et sans en-tête
NORM	1	Les réponses aux interrogations envoyées sur le bus GPIB sont uniquement numériques (autant que possible) et sans en-tête; les réponses aux interrogations envoyées sur l'affichage comportent des en-têtes et des réponses alphabétiques (autant que possible).
ALPHA		Les réponses aux interrogations envoyées sur le bus GPIB ou sur l'affichage contiennent un entête et une réponse alphabétique (autant que possible).

Type à la mise sous tension = NORM

Type par défaut = NORM

- Les équivalents décimaux des paramètres alphabétiques sont indiqués (s'il y a lieu) avec chaque commande figurant dans ce chapitre. Certaines commandes d'interrogation, telles que DEFKEY'?, renvoient toujours une réponse alphabétique, quelque soit le QFORMAT spécifié. D'autres, telles que NDIG? renvoient toujours une valeur numérique.
- Lorsque vous exécutez une commande d'interrogation à partir du panneau avant du multimètre, la réponse n'est envoyée que sur l'affichage. Lorsque vous exécutez une commande d'interrogation depuis le contrôleur, la réponse n'est envoyée que dans la mémoire-tampon de sortie du multimètre.

- Les réponses aux interrogations sont toujours retournées au format ASCII, après quoi le format de sortie revient au type précédemment spécifié (ASCII, SINT, etc.).
- **Commande d'interrogation:** La commande d'interrogation QFORMAT? renvoie le format d'interrogation couramment spécifié. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** toutes les commandes d'interrogation, OFORMAT

Exemples

NORM

```
10 OUTPUT 722;"QFORMAT NORM"
20 OUTPUT 722;"ARANGE?"
30 ENTER 722;A
40 PRINT A
50 END
```

Réponse typique: 1

NUM

```
10 OUTPUT 722;"QFORMAT NUM"
20 OUTPUT 722;"ARANGE?"
30 ENTER 722;A
40 PRINT A
50 END
```

Réponse typique: 1

ALPHA

```
10 OUTPUT 722;"QFORMAT ALPHA"
20 OUTPUT 722;"ARANGE?"
30 ENTER 722;A$
40 PRINT A$
50 END
```

Réponse typique: ARANGE ON

R

La commande R est une abréviation de la commande RANGE.

Syntaxe

R [*entrée_max*][, %*resolution*]

Pour plus de détails, voir commande **RANGE**.

RANGE

La commande RANGE vous permet de sélectionner une gamme de mesure ou le mode de gamme automatique.

Syntaxe

RANGE [*entrée_max*][, %*resolution*]

entrée_max Le paramètre *entrée_max* sélectionne une gamme fixe (standard) ou le mode de gamme automatique. Pour sélectionner une gamme fixe, spécifiez *entrée_max* comme la valeur absolue (pas de nombre négatif) de l'amplitude maximale attendue du signal d'entrée. Le multimètre sélectionne alors la gamme adéquate. Pour choisir le mode de gamme automatique, spécifiez AUTO pour *entrée_max* ou prenez la valeur par défaut du paramètre. Lorsque la gamme automatique est sélectionnée, le multimètre échantillonne le signal d'entrée avant chaque lecture et sélectionne la gamme adéquate.

- Les tableaux suivants montrent les paramètres *Entrée_max* et les gammes qu'ils sélectionnent pour chaque fonction de mesure.

For DCV:

Paramètre <i>entrée_max</i>	Sélectionne gamme	Pleine échelle
-1 ou AUTO	Gamme Auto.	
0 à 0,12	100 mV	120 mV
>0,12 à 1,2	1 V	1,2V
>1,2 à 12	10 V	12 V
>12 à 120	100 V	120 V
>120 à 1E3	1000 V	1050 V

For ACV or ACDCV:

Paramètre <i>entrée_max</i>	Sélectionne gamme	Pleine échelle
-1 ou AUTO	Gamme Auto.	
0 à 0,012	10 mV	12mV
>0,012 à 0,12	100 mV	120 mV
>0,12 à 1,2	1V	1,2V
>1,2 à 12	10 V	12V
>12 à 120	100 V	120 V
>120 à 1E3	1000 V	1050 V

For OHM or OHMF:

Paramètre <i>entrée_max</i>	Sélectionne gamme	Pleine échelle
-1 ou AUTO	Gamme Auto.	
0 à 12	10 Ω	12 Ω
>12 à 120	100 Ω	120k Ω
>120 à 1,2E3	1k Ω	1,2k Ω
>1,2E3 à 1,2E4	10k Ω	12k Ω
>1,2E4 à 1,2E5	100k Ω	120k Ω
>1,2E5 à 1,2E6	1M Ω	1,20M Ω
>1,2E6 à 1,2E7	10M Ω	12M Ω
>1,2E7 à 1,2E8	100M Ω	120M Ω
>1,2E8 à 1,2E9	1G Ω	1,2G Ω

For DCI:

Paramètre <i>entrée_max</i>	Sélectionne gamme	Pleine échelle
-1 ou AUTO	Gamme Auto.	
0 à 0,12E-6	0,1 μ A	0,12 μ A
>0,12E-6 à 1,2E-6	1 μ A	1,2 μ A
>1,2E-6 à 12E-6	10 μ A	12 μ A
>12E-6 à 120E-6	100 μ A	120 μ A
>120E-6 à 1,2E-3	1 mA	1,2 mA
>1,2E-3 à 12E-3	10 mA	12 mA
>12E-3 à 120E-3	100 mA	120 mA
>120E-3 à 1,2	1 A	1,05 A

For ACI or ACDCI:

Paramètre <i>entrée_max</i>	Sélectionne gamme	Pleine échelle
-1 ou AUTO	Gamme Auto.	
0 à 120E-6	100 μ A	120 μ A
>120E-6 à 1,2E-3	1mA	1,2mA
>1,2E-3 à 12E-3	10 mA	12mA
>12E-3 à 120E-3	100 mA	120 mA
>120E-3 à 1,2	1A	1,05A

For SSAC or SSDC:

Paramètre <i>entrée_max</i>	Sélectionne gamme	Pleine échelle
0 à 0,012	10 mV	12mV
>0,012 à 0,120	100 mV	120 mV
>0,120 à 1,2	1V	1,2V
>1,2 à 12	10 V	12V
>12 à 120	100 V	120 V
>120 à 1E3	1000 V	1050 V

For DSAC or DSDC:

Paramètre <i>entrée_max</i>	Sélectionne gamme	Pleine échelle	
		Format SINT	Format DINT
0 à 0,012	10 mV	12mV	50 mV
>0,012 à 0,120	100 mV	120 mV	500 mV
>0,120 à 1,2	1V	1,2V	5.0 V
>1,2 à 12	10 V	12V	50 V
>12 à 120	100 V	120 V	500 V
>120 à 1E3	1000 V	1050 V	1050 V

Entrée_max à la mise sous tension = AUTO.

Entrée_max par défaut = AUTO.

%_resolution Pour toutes les fonctions, exceptées celles de numérisation (DSAC, DSDC, SSAC et SSDC), le paramètre **%_resolution** spécifie la résolution de la mesure. (Le multimètre ignore ce paramètre lorsqu'il est inclus dans une commande de numérisation). Pour les mesures de fréquence et de période, vous spécifiez **%_resolution** comme le nombre de chiffres à résoudre. Pour les fonctions de mesure restantes (DCV, ACY, ACDCV, OHM, OHMF, DCI et ACI), vous spécifiez **%_resolution** comme un pourcentage du paramètre d'entrée max. Le multimètre multiplie alors **%_resolution** par **entrée_max** pour déterminer la résolution de la mesure.

Supposons par exemple que l'entrée maximale attendue soit de 10 V et que vous vouliez une résolution de 1 m V. Pour déterminer le paramètre `%_resolution`, utilisez l'équation:

$$\%\_resolution = (\text{résolution actuelle} / \text{entrée max}) \times 100$$

Pour cet exemple, l'équation donne

$$\%\_resolution = (0,001/10) \times 100 = 0,01$$

REMARQUE

Quand vous utilisez la gamme automatique, le multimètre multiplie le paramètre `%_resolution` par la lecture pleine échelle de la gamme sélectionnée. Le résultat est la résolution minimale. Le multimètre vous donne toujours au moins la résolution minimale et, dans de nombreux cas, vous donne un chiffre de résolution supplémentaire.

`%_resolution` à la mise sous tension = aucun. A la mise sous tension, la résolution est déterminée par la commande NPLC qui donne 8,5 chiffres. (La valeur de mise sous tension de la commande NDIG masque 1 chiffre d'affichage; le multimètre n'affiche donc que 7,5 chiffres. Vous pouvez utiliser la commande NDIG 8 pour afficher les 8,5 chiffres; pour plus de détails à ce sujet, voir commande **NDIG**).

`%_resolution` par défaut:

Pour les mesures de fréquence ou de période, le paramètre `%_resolution` par défaut est de 0,00001, ce qui sélectionne un temps de porte de 1 s et 7 chiffres de résolution.

Pour les mesures de tension alternative ou alternative+ continue (ACV ou ACDCV), le paramètre `%_resolution` par défaut est de 0,01 % pour SETACV SYNC (méthode de mesure synchrone) ou de 0,4% pour SETACV RNDM (méthode de mesure aléatoire).

Pour toutes les autres fonctions de mesure, la résolution par défaut est déterminée par le temps d'intégration courant.

Points importants

- **Commande d'interrogation:** La commande d'interrogation RANGE? renvoie la gamme de mesure courante. (RANGE? ne donne aucune indication sur le mode de la gamme; utilisez la commande ARANGE? pour savoir si le mode de gamme automatique est validé ou pas). Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.

– **Commandes connexes:** ARANGE, FUNC, R

Exemples

Dans le programme suivant, la ligne 10 laisse le *%_resolution* de la ligne 30 contrôler la résolution. La résolution spécifiée par la ligne 30 est de 10 mΩ.

```
10 OUTPUT 722;"NPLC 0"           !PLC AU MINIMUM
20 OUTPUT 722;"OHM"              !SELECTIONNE LES MESURES DE
25                               !RESISTANCE 2-FILS
30 OUTPUT 722;"RANGE 800,.00125" !SELECTIONNE 800Ω MAX,
35                               !RESOLUTION 10 mΩ
40 END!
```

RATIO

La commande RATIO demande au multimètre de mesurer une tension de référence continue appliquée sur les bornes **Ω Sense** et la tension du signal appliquée aux bornes **Input** (Entrée). Le multimètre calcule alors le rapport:

$$\text{Rapport} = \frac{\text{Tension du signal}}{\text{Tension de référence cc}}$$

Syntaxe

RATIO [*contrôle*]

contrôle

Paramètre contrôle	Équivalent numérique	Description
OFF	0	Invalide les mesures de rapport
ON	1	Valide les mesures de rapport en utilisant la fonction de mesure courante (DCV, ACV ou ACDCV)

Contrôle à la mise sous tension = OFF

Contrôle par défaut = ON

Points importants

- Les bornes **Ω Sense LO** et **Input LO** doivent avoir une référence commune et ne pas présenter une différence de tension $>0,25$ V.
- La tension du signal peut être mesurée à l'aide de la fonction de mesure DCV, ACV ou ACDCV. (Pour ACV ou ACDCV, les trois méthodes de mesure - ANA, RNDM ou SYNC - sont acceptées). Le multimètre utilise toujours DCV pour mesurer la tension de référence. La gamme de tensions de référence mesurables est de ± 12 V cc (gamme automatique uniquement). Pour spécifier une mesure de rapport, sélectionnez d'abord la fonction de mesure (et la méthode de mesure pour ACV ou ACDCV), puis validez les mesures de rapport à l'aide de la commande **RATIO** (voir exemple ci-dessous).
- **Commande d'interrogation**: La commande d'interrogation **RATIO?** renvoie le mode de rapport courant. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes**: ACDCV, ACV, DCV, SETACV

Exemple

```

10 OUTPUT 722;"PRESET NORM" !SUSPEND LES LECTURES,NRDGS=1
20 OUTPUT 722;"ACV"         !SELECTIONNE LES MESURES DE TENSION
25                           !ALTERNATIVE
30 OUTPUT 722;"SETACV SYNC" !METHODE DE MESURE SYNCHRONNE
40 OUTPUT 722;"RATIO ON"    !VALIDE LES MESURES DE RAPPORT
50 OUTPUT 722;"TRIG SGL"    !DECLENCHE LA MESURE
60 ENTER 722;A              !ENTRE LE RAPPORT
70 PRINT A                  !IMPRIME LE RAPPORT
80 END

```

RES

Resolution. La commande RES spécifie la résolution comme un pourcentage de la gamme de mesure.

Syntaxe

RES [%_resolution]

%_resolution Pour les mesures de fréquence et de période, le paramètre %_resolution spécifie les chiffres de résolution et le temps de porte comme illustré ci-dessous (%_resolution affecte également la vitesse de lecture; voir **Annexe A :**

Spécifications” à la page 411 pour plus de détails.) Si vous prenez la valeur par défaut du paramètre `%_resolution` pour les mesures de fréquence ou de période, le multimètre utilise 0,00001.

Paramètre <code>%_resolution</code>	Sélectionne le temps de porte	Chiffres de résolution
0,00001	1 s	7
0,0001	100 ms	7
0,001	10 ms	6
0,01	1 ms	5
0,1	100 µs	4

Pour toutes les autres fonctions (exceptées DSAC, DSDC, SSAC et SSDC; `%_resolution` est ignore pour ces fonctions), le multimètre multiplie `%_resolution` par la gamme de mesure courante (1V, 10V, 100V, etc) pour déterminer la résolution. Pour déterminer le paramètre `%_resolution`, utilisez l'equation:

$$\%_resolution = (résolution\ actuelle / entrée\ max) \times 100$$

Supposons par exemple que vous mesuriez une tension continue dans la gamme 10V et que vous vouliez une résolution de 100 µV. Pour cet exemple, l'équation donne:

$$\%_resolution = (0,0001 / 10) \times 100 = 0,001$$

`%_resolution` a la mise sous tension = aucun. A la mise sous tension, la résolution est déterminée par la commande NPLC qui donne 8,5 chiffres. (La valeur de mise sous tension de la commande NDIG masque 1 chiffre d'affichage; le multimètre n'affiche donc que 7,5 chiffres. Vous pouvez utiliser la commande NDIG 8 pour afficher les 8,5 chiffres; pour plus de détails à ce sujet, voir commande NDIG).

`%_resolution` par défaut:

Pour les mesures de fréquence ou de période, le paramètre `%_resolution` par défaut est de 0,00001, ce qui sélectionne un temps de porte de 1 s et 7 chiffres de résolution.

Pour les mesures de tension alternative ou alternative + continue (ACV ou ACDCV), le paramètre `%_resolution` par défaut est de 0,01% pour SETACV

SYNC (méthode de mesure synchrone) ou de 0,4% pour SETACV RNDM (méthode de mesure aléatoire).

Pour toutes les autres fonctions de mesure, la résolution par défaut est déterminée par le temps d'intégration courant.

Points importants

- Le paramètre *%_resolution* de la commande RES n'opère pas tout à fait de la même façon que le paramètre *%_resolution* d'une commande de fonction (FUNC, ACV, DCV, etc.) ou que celui de la commande RANGE. Lorsqu'il est utilisé avec la commande RES, *%_resolution* est multiplié par la gamme pour déterminer la résolution réelle. Lorsqu'il est utilisé avec une commande de fonction ou la commande RANGE, *%_resolution* est multiplié par le paramètre *entrée_max* de la commande. Le paramètre *entrée_max* ne correspond pas obligatoirement à la valeur d'une gamme de mesure.
- **Commande d'interrogation:** La commande d'interrogation RES? renvoie la valeur du paramètre *%_resolution*. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** ACDCI, ACDCV, ACI, ACV, APER, DCI, DCV, FREQ, FUNC, NPLC, OHM, OHMF, PER, RANGE

Exemples

Dans le programme suivant, la ligne 10 laisse le *%_resolution* de la ligne 30 contrôler la résolution..

```
10 OUTPUT 722;"NPLC 0" !PLC AU MINIMUM
20 OUTPUT 722;"DCV 6," !SELECTIONNE VOLTS CC, GAMME 10V
30 OUTPUT 722;"RES .001" !100 V DE RESOLUTION SUR LA GAMME 10 V
40 END
```

Dans le programme suivant, la ligne 10 définit le nombre de périodes secteur (PLC) à 1000, ce qui correspond à la résolution maximale (7,5 chiffres) et empêche la commande RES de la ligne 30 d'affecter la mesure. La résolution demandée à la ligne 30 est de 10 m.Ω mais du fait de la ligne 10, la résolution réelle sera de 100 μΩ.

```
10 OUTPUT 722;"NPLC 1000" !PLC AU MAXIMUM
20 OUTPUT 722;"OHM 1E3      !SELECTIONNE RESISTANCE 2-FILS,
25                                !GAMME 1 kΩ
30 OUTPUT 722;"RES .001    !10 mΩ DE RESOLUTION
40 END
```

RESET

La commande RESET vous permet de configurer le 3458A à l'état de mise sous tension sans avoir à mettre l'appareil hors tension.

Syntaxe

RESET

Points importants

- La commande RESET:

Abandonne les lectures en cours

Efface les registres d'erreur et d'erreur auxiliaire

Efface le registre d'état sauf le bit de SRQ de mise sous tension (bit 3)

Efface la mémoire de lecture.

De plus, la commande RESET exécute également les commandes suivantes:

ACBAND 20,2E6	MMATH OFF
AZERO ON	NDIG 7
DCV AUTO	NPLC 10
DEFEAT OFF	NRDGS 1,AUTO
DELAY -1	OCOMP OFF
DISP ON	OFORMAT ASCII QFORMAT NORM
EMASK 32767 (tous les bits sont validés)	RATIO OFF
END OFF	RQS 0
EXTOUT ICOMP,NEG	SETACV ANA
FIXEDZ OFF	SLOPE POS
FSOURCE ACV	SSRC LEVEL,AUTO
INBUF OFF	SWEEP 100E-9,1024
LEVEL 0,AC	TARM AUTO
LFILTER OFF	TBUFF OFF
LFREQ	TIMER 1
LOCK OFF	TRIG AUTO
MATH OFF	
MEM OFF (dernière opération mémoire définie à FIFO)	
MFORMAT SREAL	

Tous les registres mathématiques sont à 0 exceptés:

```
DEGREE = 20
SCALE  = 1
PERC   = 1
REF    = 1
RES    = 50
```

- Bien que la commande RESET puisse être utilisée à distance, elle est principalement conçue pour une utilisation à partir du panneau avant. La commande RESET configure le 3458A dans un état de départ connu et intéressant pour un fonctionnement local. L'exécution de la commande RESET à partir du menu alphabétique reconfigure le multimètre comme indiqué ci-dessus. Le fait d'appuyer sur la touche Shift-Reset du panneau avant équivaut toutefois à une mise hors tension de l'instrument. L'état courant du multimètre est sauvegardé comme état 0, les sous-programmes comprimés sont supprimés, les lectures enregistrées sont effacées, le bit de SRQ de mise sous tension est positionné dans le registre d'état et la séquence de mise sous tension s'exécute.
- Si vous essayez d'envoyer la commande RESET à partir d'un contrôleur, il est possible que le multimètre soit occupé ou que le bus GPIB soit pris. Dans l'un ou l'autre cas, le multimètre ne répondra pas immédiatement à la commande RESET à distance. Vous devez donc envoyer la commande GPIB Clear Device (Libérer appareil) avant d'envoyer la commande RESET du multimètre, comme illustré ci-dessous:
- **Commandes connexes:** PRESET

Exemple

```
10 CLEAR 722                !LIBERE IMMEDIATEMENT LE MULTIMETRE
20 OUTPUT 722;"RESET"       !REINITIALISE LE MULTIMETRE
30 END
```

REV?

Revision query. La commande d'interrogation REV? renvoie deux nombres, séparés par une virgule. Le premier est le numéro de révision du logiciel résident du processeur maître du multimètre; le second est celui du logiciel résident du processeur esclave.

Syntaxe

REV?

Exemple

```
10 OUTPUT 722; "REV?" !LIT LE NUMERO DE REVISION DU
15                      !LOGICIEL RESIDENT
20 ENTER 722; A, B     !ENTRE LES NUMEROS DANS CES VARIABLES
30 PRINT A, B          !IMPRIME LES NUMEROS
40 END
```

RMATH

Recall math. La commande RMATH (rappel math) lit et renvoie le contenu d'un registre mathématique.

Syntaxe

RMATH [*registre*]

registre Les valeurs possibles du paramètre registre sont:

Paramètre <i>registre</i>	Équivalent numérique	Contenu du registre
DEGREE	1	Constante de temps pour FILTER et RMS
LOWER	2	La plus petite valeur lue dans STATS
MAX	3	Limite supérieure pour la fonction PFAIL
MEAN	4	Moyenne des lectures dans STATS
MIN	5	Limite inférieure pour PFAIL
NSAMP	6	Nombre d'échantillons dans STATS

Paramètre registre	Équivalent numérique	Contenu d u registre
OFFSET	7	Quantité à soustraire dans les fonctions NULL et SCALE
PERC	8	Valeur de% pour la fonction PERC
REF	9	Valeur de référence pour la fonction DB
RES	10	Impédance de référence pour la fonction DBM
SCALE	11	Diviseur dans la fonction SCALE
SDEV	12	Ecart type dans STATS
UPPER	13	La plus grande valeur lue dans STATS
HIRES	14	Utilisé par aucun registre mathématique (registre supplémentaire)
PFAILNUM	15	Nombre de lectures «réussies» avant détection d'un dépassement par la fonction PFAIL

registre à la mise sous tension = sans
registre par défaut = DEGREE

Points importants

- Le contenu des registres mathématiques est toujours envoyé au format ASOI, quelque soit le format de sortie spécifié. Une fois le contenu du registre envoyé, le format de sortie revient à la valeur à laquelle il avait été précédemment spécifié (SINT, DINT, SREAL, DREAL ou ASCII.
- **Commandes connexes:** MATH, MMATH, SMATH

Exemple

```
10 OUTPUT 722;"TRIG HOLD"      !SUSPEND LE DECLenchement
20 OUTPUT 722;"MEM FIFO"        !VALIDE LA MEMOIRE DE LECTURE, MODE FIFO
30 OUTPUT 722;"NRDGS 10"        !10 LECTURES/DECLenchement
40 OUTPUT 722;"DCV 3"           !TENSION CONTINUE, GAMME 10 V
50 OUTPUT 722;"MATH STAT"       !VALIDE L'OPERATION MATHEMATIQUE
55                               !"STATISTIQUES"
60 OUTPUT 722;"TRIG SGL"        !DECLenche 1 FOIS LE MULTIM7RE
70 OUTPUT 722;"RMATH SDEV"      !LIT L'ECART TYPE
80 ENTER 722;A                  !ENTRE L'ECART TYPE
90 PRINT A                       !IMPRIME L'ECART TYPE
100 END
```

RMEM

Recall memory. La commande RMEM (rappel mémoire) lit et retourne la valeur d'une lecture ou d'un groupe de lectures particulier dans la mémoire de lecture. Cette commande n'affecte pas les lectures enregistrées

Syntaxe

RMEM [*première*][, *nombre*][, *enregistrement*]

première Le paramètre *première* désigne la lecture de début.

première à la mise sous tension = sans.

première par défaut = 1

nombre Le paramètre *nombre* indique le nombre de lectures à rappeler, en commençant à la *première*.

nombre à la mise sous tension = sans.

nombre par défaut = 1

enregistrement Le paramètre *enregistrement* désigne l'enregistrement à partir duquel vous voulez rappeler les lectures. Les enregistrements correspondent au nombre de lectures spécifié avec la commande NRDGS. Par exemple, si vous avez spécifié trois lectures dans la commande NRDGS, chaque enregistrement contient trois lectures.

enregistrement à la mise sous tension = sans.

enregistrement par défaut = 1

Points importants

- La commande RMEM inactive automatiquement la mémoire de lecture (MEM OFF). Cela signifie que toutes les lectures précédemment enregistrées restent intactes et que les nouvelles lectures ne seront pas enregistrées. Utiliser la commande MEM CONT pour revalider la mémoire de lecture sans effacer les lectures enregistrées.
- Le 3458A affecte un numéro à chaque lecture dans la mémoire de lecture. La lecture la plus récente reçoit le numéro le plus faible (1) et la plus ancienne a le numéro le plus élevé. Les numéros sont toujours attribués de cette façon quelque soit le mode (FIFO ou LIFO) que vous utilisez. Les enregistrements

sont également numérotés de cette façon l'enregistrement le plus récent est l'enregistrement numéro 1.

- Quand vous exécutez la commande RMEM à partir du panneau avant, les lectures sont copiées, une par une, sur l'affichage. Après avoir visualisé la première lecture, vous pouvez obtenir les autres en utilisant les touches flèche vers le haut ou flèche vers le bas. Utiliser les touches flèche vers la gauche et vers la droite pour visualiser le numéro de la lecture (côté gauche de l'affichage).
- Sans utiliser la commande RMEM, vous pouvez également rappeler des lectures en utilisant la "lecture implicite". Référez-vous à la **Rappel des lectures** dans le **chapitre 4** pour plus l'informations sur l'utilisation de la "lecture implicite".
- **Commandes connexes:** MCOUNT?, MEM, MFORMAT, MSIZE, NRDGS

Exemple

10 OUTPUT 722;"TARM HOLD"	! INTERROMPT LE DECLENCHEMENT
20 OUTPUT 722;"DCV"	! MESURES DE TENSION CONTINUE
30 OUTPUT 722)"TRIG AUTO"	! DECLENCHEMENT AUTOMATIQUE
40 OUTPUT 722;"NRDGS 3 ,AUTO"	! 3 LECTURES PAR EVENEMENT
45	! D'ECHANTILLONNAGE (AUTO)
50 OUTPUT 722;"MEM FIFO"	! VALIDE LA MEMOIRE DE LECTURE,
60 OUTPUT 722;"TARM SGL, 10"	! COMMANDE AU 3458A D'EFFECTUER
65	! 10 GROUPES DE LECTURES
70 OUTPUT 722;"RMEM 1,3,6"	! RAPPELLE LES 1ERE, 2EME, & 3EME
75	! LECTURES DU 6EME GROUPE
80 ENTER 722;A,B,C	! ENTRE LES LECTURES DANS LES
85	! A, B, & C
90 PRINT A,B,C	! AFFICHE LES LECTURES
100 END	

RQS

Request service. La commande RQS (request service= demande de service) spécifie quelles conditions du registre d'état positionneront la ligne SRQ sur le bus GPIB.

Syntaxe

RQS [*valeur*]

valeur Vous validez une condition en spécifiant sa valeur décimale pondérée comme paramètre valeur. Pour plus d'une condition, spécifiez la somme des valeurs pondérées. Les conditions et les valeurs correspondantes sont:

Valeur pondérée	Numéro de bit	Valide la condition
1	0	Exécution de la mémoire de programme terminée
2	1	Limite Haute ou Basse dépassée
4	2	SRQ du panneau avant
8	3	SRQ de mise sous tension
16	4	Prêt
32	5	Erreur (Consulter le registre d'erreur)
64	6	Service demandé (vous ne pouvez invalider ce bit)
128	7	Données disponibles

valeur à la mise sous tension: si le SRQ de mise sous tension était validé quand l'instrument a été éteint, valeur= 8. Sinon. valeur= 0.

valeur par défaut= 0 (pas de conditions validées).

Points importants

- Vous pouvez contrôler les erreurs qui affecteront le bit 5 en utilisant la commande EMASK.
- Le bit de SRQ de mise sous tension est enregistré en mémoire non-volatile. Tous les autres bits sont effacés à la mise sous tension.

-
- **Commande d'interrogation:** La commande d'interrogation RQS? renvoie la somme pondérée de tous les bits validés dans le registre d'état.
- **Commandes connexes:** CSB, SPOLL (commande GPIB), STB?

Exemples

```

OUTPUT 722;"RPS 4"    !VALIDE LE SRQ DE PANNEAU AVANT
OUTPUT 722;"RQS 40"   !VALIDE LE SRQ DE MISE SOUS TENSION (8)
                        ! & LES CONDITIONS D'ERREUR (32)
OUTPUT 722;"RQS 255"  !VALIDE TOUTES LES CONDITIONS
OUTPUT 722;"RQS 0"    !VALIDE TOUTES LES CONDITIONS

```

RSTATE

Recall state. La commande RSTATE rappelle un état enregistré de la mémoire et configure le multimètre dans cet état. Les états sont enregistrés en mémoire avec la commande SSTATE.

Syntaxe

RSTATE [*nom*]

nom Nom de l'état. Un nom d'état peut comporter jusqu'à 10 caractères alphabétiques ou alphanumériques ou être un entier compris entre 0 et 127. Pour plus de détails à ce sujet, voir commande **SSTATE**.

Nom à la mise sous tension= aucun

Nom par défaut = 0

Points importants

- A chaque fois que le multimètre est mis hors tension, son état est enregistré dans l'état 0. Après une coupure secteur, le multimètre peut rapidement être reconfiguré à son précédent état à l'aide de la commande RSTATE 0.
- Si la fonction mathématique NULL en temps réel a été validée dans un état enregistré, au rappel de cet état, la première lecture est placée dans le registre OFFSET (Décalage; pour plus de détails à ce sujet, voir opération **NULL** dans le chapitre 4).
- Vous pouvez afficher le nom de tous les états enregistrés à partir du panneau avant en appuyant sur la touche Recall State et en utilisant les touches flèche

vers le haut et vers le bas pour les faire défiler. Dès que 1' état recherché s'affiche, vous pouvez appuyer sur la touche Enter pour le rappeler.

- **Commandes connexes:** MSIZE, PURGE, SCRATCH, SSTATE

Exemple

```
OUTPUT 722; "RSTATE B2" !RAPPEL DE L'ETAT B2
```

SCAL

SCAL est une commande d'étalonnage. Pour plus de détails à son sujet, se reporter au manuel d'étalonnage du 3458A (en anglais).

SCRATCH

La commande SCRATCH efface tous les sous-programmes et tous les états enregistrés en mémoire

Syntaxe

SCRATCH

Points importants

- Vous pouvez supprimer un sous-programme particulier à l'aide de la commande DELSUB et un état particulier à l'aide de la commande PURGE.
- **Commandes connexes:** DELSUB, PURGE, RSTATE, SSTATE, SUB

Exemple

```
OUTPUT 722;"SCRATCH" !SUPPRIME TOUS LES SOUS-PROGRAMMES ET  
!TOUS LES ETATS ENREGISTRES
```

SECURE

Security code. La commande SECURE permet au responsable de l'étalonnage de spécifier un code de sécurité pour empêcher un étalonnage accidentel, non autorisé ou un étalonnage automatique de l'appareil. (Pour plus de détails sur l'étalonnage automatique, voir commande **ACAL** dans ce chapitre).

Syntaxe

SECURE *ancien_code*, *nouveau_code* [,*protection_acal*]

ancien_code Ancien code de sécurité du multimètre. Le multimètre est expédié de l'usine avec le code de sécurité 3458A.

nouveau_code Nouveau code de sécurité. Le code doit être un entier compris entre -2.1E-9 et 2.1E9. Si le nombre spécifié n'est pas un entier, le multimètre l'arrondit à une valeur entière.

protection_acal Vous permet de protéger un étalonnage automatique. Les valeurs possibles sont:

Paramètre <i>acal_secure</i>	Équivalent numérique	Description
OFF	0	Invalide la fonction de protection de l'étalonnage automatique; aucun code requis pour autocal
ON	1	Valide la fonction de protection de l'étalonnage automatique; code de sécurité obligatoire pour autocal (voir exemple ACAL).

***Protection_acal* à la mise sous tension** = valeur précédemment spécifiée (valeur OFF au départ usine)

***Protection_acal* par défaut** = OFF

Points importants

- Si vous spécifiez 0 pour le *nouveau_code*, la fonction de sécurité est invalidée et vous n'avez plus aucun code à entrer pour exécuter un étalonnage ou un autocal (étalonnage automatique).
- La touche **Last Entry** (dernière entrée) du panneau avant n'affichera pas les codes précédemment utilisés dans une commande SECURE.
- **Commandes connexes:** ACAL, CAL, CALNUM?, CALSTR, SCAL

Exemples

Changement du code

```
OUTPUT 722;"SECURE 3458,4448,ON" !MODIFIE LE CODE DE SECURITE USINE  
!A 4448, VALIDE LA PROTECTION_ACAL
```

Invalidation du code

```
OUTPUT 722;"SECURE 3458,0" !INVALIDE LE CODE DE SECURITE  
!POUR L'ETALONNAGE ET  
!L'ETALONNAGE AUTOMATIQUE
```


SETACV

Set ACV. La commande SETACV sélectionne la méthode Conversion RMS pour les mesures de tension alternative ou alternative + continue.

Syntaxe

SETACV [*type*]

type Le paramètre type sert à sélectionner la méthode de mesure: analogique, échantillonnage aléatoire ou synchrone. Les valeurs possibles du paramètre type sont:

Paramètre <i>type</i>	Équivalent numérique	Description
ANA	1	Conversion analogique de la valeur efficace (RMS)
RNDM	2	Conversion d'échantillons aléatoires
SYNC	3	Conversion d'échantillons synchrones

Type à la mise sous tension = ANA

Type par défaut = ANA

Points importants

- Les limites de la largeur de bande varient en fonction de la méthode de conversion choisie. Pour plus de détails, voir **Annexe A : Spécifications** à la page 411.
- **Commande d'interrogation:** La commande d'interrogation SETACV? renvoie la méthode de mesure ca courante. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** ACBAND, ACDCV, ACV, FUNC, SSRC

Exemple

```
10 OUTPUT 722; "SETACV SYNC" !SELECTIONNE L'ECHANTILLONNAGE SYNCHROME
15                               !(COUPLAGE CC)
20 OUTPUT 722; "ACDCV"         !SELECTIONXE LES MESURES DE TENSION
25                               !ALTERNATIVE+ CONTINUE
```

30 END

SLOPE

Utilisée conjointement avec la commande LEVEL, la commande SLOPE permet de spécifier la pente du signal qui sera utilisée par les circuits de détection de niveau.

Syntaxe

SLOPE [*pente*]

pente Sélectionne la pente (vers le positif ou vers le négatif) du signal d'entrée qui sera utilisée par les circuits de détection de niveau. Les valeurs possibles pour le paramètre pente sont:

Paramètre <i>pente</i>	Équivalent numérique	Description
NEG	0	Sélectionne la pente négative
POS	1	Sélectionne la pente positive

Pente à la mise sous tension = POS

Pente par défaut = POS

Points importants

- **Commande d'interrogation:** La commande d'interrogation SLOPE? renvoie la pente couramment sélectionnée. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** LEVEL, LFILTER, NRDGS, SSRC, TRIG

Exemple

```
OUTPUT 722;"SLOPE POS" !SELECTIONNE LA PENTE POSITIVE
                        !POUR LA DETECTION DE NIVEAU
```

SMATH

Store math. La commande SMA TH (store math enregistrement math) place un nombre dans un registre mathématique.

Syntaxe

SMATH [*registre*][,*nombre*]

registre Les valeurs possibles du paramètre registre sont:

Paramètre registre	Équivalent numérique	Contenu d u registre	Valeur à la mise sous tension
DEGREE	1	Constante de temps pour FILTER et RMS	20
LOWER	2	La plus petite valeur lue dans STATS	0
MAX	3	Limite supérieure pour la fonction PFAIL	0
MEAN	4	Moyenne des lectures dans STATS	0
MIN	5	Limite inférieure pour PFAIL	0
NSAMP	6	Nombre d'échantillons dans STATS	0
OFFSET	7	Quantité à soustraire dans les fonctions NULL et SCALE	0
PERC	8	Valeur de% pour la fonction PERC	1
REF	9	Valeur de référence pour la fonction DB	1
RES	10	Impédance de référence pour la fonction DBM	50
SCALE	11	Diviseur dans la fonction SCALE	1
SDEV	12	Ecart type dans STATS	0
UPPER	13	La plus grande valeur lue dans STATS	0
HIRES	14	Utilisé par aucun registre mathématique (registre supplémentaire)	0
PFAILNUM	15	Nombre de lectures "réussies" avant détection d'un dépassement par la fonction PFAIL	0

registre par défaut = DEGREE.

registre à la mise sous tension = voir liste ci-dessus.

nombre Utilisez comme paramètre nombre la valeur que vous voulez placer dans le registre.

nombre par défaut = dernière lecture.

nombre à la mise sous tension = voir liste ci-dessus.

Points importants

- Vous pouvez utiliser la commande SMATH pour placer un nombre dans l'un des registres où sont enregistrées des lectures (UPPER, LOWER, etc.), cependant cette valeur sera remplacée par une lecture si la fonction mathématique correspondante est validée (par ex, STATS).
- Vous ne pouvez utiliser -1 (moins 1) comme paramètre nombre par défaut. En spécifiant -1, vous écrivez effectivement -1 dans le registre.
- **Commandes connexes:** MATH, MMATH, RMATH

Exemples

```
OUTPUT 722;"SMATH 11,1E-3" !PLACE LA VALEUR "1E-3" DANS LE REGISTRE
!SCALE
```

Dans le programme suivant, les lignes 10 et 20 mesurent la valeur d'une résistance connectée au 3458A. La ligne 30 déclenche la mesure de résistance. La ligne 40 prend le paramètre nombre par défaut et la lecture est enregistrée dans le registre RES. La ligne 50 demande à l'opérateur de connecter la source de tension au 3458A. La ligne 80 valide la fonction mathématique DBM. Ce programme affiche la puissance fournie à la résistance en DB (résultat de la fonction mathématique DBM).

```
10 OUTPUT 722;"PRESET NORM" !PRECONFIGURATION : TARM AUTO, TRIG SYN,
15 !NRDGS 1, AUTO
20 OUTPUT 722;"OHM" !MESURES DE RESISTANCES 2-FILS
30 OUTPUT 722;"TRIG SGL" !DECLENCHE UNE FOIS
40 OUTPUT 722;"SMATH RES" !PLACE LA LECTURE DANS LE REGISTRE RES
50 DISP "CONNECT SOURCE; PRESS CONT" !MESSAGE
55 !OPERATEUR
60 PAUSE !SUSPEND L'EXECUTION DU PROGRAMME
70 OUTPUT 722;"ACV" !MESURES DE TENSION ALTERNATIVE
```

```

80 OUTPUT 722;"MATH DBM"      !VALIDE LA FONCTION MATH DBM
90 OUTPUT 722;"TRIG AUTO"     !DECLENCHE AUTOMATIQUEMENT
100 END

```

SRQ

Service request. La commande SRQ positionne le bit 2 du registre d'état du multimètre. Si le bit 2 est positionné pour générer une demande de service (commande RQS 4), l'exécution de la commande SRQ positionnera la ligne SRQ du bus GPIB.

Syntaxe

SRQ

– **Commandes connexes:** CSB, EXTOUT, RQS, SPOLL (commande GPIB), STB?

Exemple

```
10 OUTPUT 722;"RQS 4" !VALIDE LE BIT 2 DU REGISTRE D'ETAT POUR
15                      !UNE DEMANDE DE SERVICE
20 OUTPUT 722;"SRQ"   !POSITIONNE LE BIT 2, SERVICE DEMANDE
30 END
```

SSAC, SSDC

Sous-échantillonnage. Configure le multimètre pour des mesures de tension sous-échantillonnées. La fonction SSAC ne mesure que la composante alternative du signal d'entrée. La fonction SSDC mesure les composantes alternative et continue combinées du signal. A ce détail près, les deux fonctions sont identiques. Pour des mesures sous-échantillonnées, le signal d'entrée doit être périodique (répétitif). Ce type de mesure utilise le circuit Suivre et Retenir (ouverture: 2 nanosecondes) et une large bande d'entrée (largeur de bande: 12MHz).

Syntaxe

SSAC [*entrée_max*] [, *%_resolution*]

SSDC [*entrée_max*] [, *%_resolution*]

entrée_max Sélectionne la gamme de la mesure (vous ne pouvez pas utiliser la fonction de changement de gamme automatique pour les mesures sous-échantillonnées). Pour sélectionner une gamme, spécifiez *entrée_max* comme l'amplitude crête attendue du signal d'entrée. Le tableau suivant montre les paramètres *entrée_max* et les gammes qu'ils sélectionnent respectivement.

Paramètre <i>entrée_max</i>	Sélectionne la gamme	Pleine échelle
0 à 0,012	10 mV	12 mv
>0,012 à 0,120	100 mV	120 mV
>0,120 à 1,2	1 V	1,2 V
>1,2 à 12	10 V	12 V
>12 à 120	100 V	120 V
>120 à 1E3	1000 V	1050 V

Entrée_max à la mise sous tension = non applicable
Entrée_max par défaut = 10 V

%_resolution Ce paramètre est ignoré par le multimètre lorsqu'il est utilisé avec la commande SSAC ou SSDC. Il ne figure dans la syntaxe que pour des raisons de cohérence avec les autres commandes de fonction (FUNC, ACI, DCV, etc.).

Points importants

- Les fonctions de zéro automatique et de gamme automatique ne peuvent pas être utilisées avec les mesures sous-échantillonnées. Si ces fonctions sont validées, elles sont suspendues lorsque la commande SSAC ou SSDC est exécutée.
- Comme pour l'échantillonnage direct, vous pouvez spécifier un niveau de tension de déclenchement jusqu'à 500% de la gamme. Le format SINT (obligatoire) ne peut toutefois traiter les échantillons supérieurs à 120% de la gamme.
- Si la mémoire de lecture est invalidée lorsque vous exécutez la commande SSAC ou SSDC, le multimètre définira automatiquement le format de sortie à SINT (le format de mémoire n'est pas modifié). Si plus tard, vous changez de fonction de mesure, le format de sortie reprend sa précédente valeur. Vous devez utiliser le format de sortie SINT lorsque vous procédez à un sous-échantillonnage et que vous transmettez directement les échantillons par le bus GPIB. Vous pouvez toutefois spécifier le format de sortie de votre choix si les échantillons sont d'abord placés en mémoire de lecture (voir remarque suivante). Pour ce faire, vous devez valider la mémoire de lecture avant d'exécuter la commande SSAC ou SSDC (l'exécution de l'une ou l'autre

de ces commandes ne convertit pas le format de sortie à SINT si la mémoire de lecture est validée).

- Si vous procédez à un sous-échantillonnage avec la mémoire de lecture validée, celle-ci doit être en mode FIFO, doit être vide (l'exécution de la commande MEME FIFO efface la mémoire de lecture) et le format de mémoire doit être SINT avant que l'événement d'armement de déclenchement ne se produise. Dans le cas contraire, le multimètre génère l'erreur SETIINGS CONFLICT (conflit de configuration) lorsque l'événement d'armement de déclenchement se produit et aucun échantillon n'est mesuré.
- En mode sous-échantillonnage, les événements de déclenchement et d'échantillonnage sont ignorés (ces événements sont décrits au [chapitre 4](#)). Les seuls événements de déclenchement qui s'appliquent au sous-échantillonnage sont l'événement d'armement de déclenchement (commande TARM) et l'événement Source de synchronisation (commande SSRC).
- En mode sous-échantillonnage, les échantillons sont pris sur plusieurs périodes du signal d'entrée. Quand les échantillons sont directement enregistrés en mémoire de lecture (commande MEM), le multimètre reclasse automatiquement les échantillons pour produire un signal composite. Quand les échantillons sont dirigés sur la mémoire-tampon de sortie, le contrôleur doit utiliser un algorithme pour reconstituer le signal composite. Les paramètres de cet algorithme sont fournis par la commande SSP ARM?.
- L'intervalle _réel entre les échantillons et le nombre total d'échantillons pris sont spécifiés par la commande SWEEP. (Vous ne pouvez pas utiliser la commande NRDGS pour le sous-échantillonnage). Le multimètre utilisera autant de périodes du signal d'entrée que nécessaire pour obtenir l'intervalle _réel spécifié. En mode sous-échantillonnage, l'intervalle réel minimal est de 10 nanosecondes (se reporter au [chapitre 5](#) pour plus de détails sur le principe de [Sous-échantillonnage](#)).
- **Commandes connexes:** DSAC, DSDC, FUNC, ISCALE?, LEVEL, LFILTER, MEM FIFO, SLOPE, PRESET FAST, PRESET DIG, SSDC, SSPARM?, SSRC, SWEEP, TARM

Exemples

Dans le programme suivant par exemple, les données sous-échantillonnées sont enregistrées en mémoire de lecture sous le format SINT (obligatoire). Le multimètre place les échantillons en mémoire dans l'ordre correct. Les

échantillons sont ensuite transmis au contrôleur sous le format de sortie DREAL (lorsque vous placez d'abord les échantillons en mémoire de lecture, le format de sortie n'est plus limité à SINT).

```

10 OPTION BASE 1                !BORNE INFERIEURE DU TABLEAU A 1
20 REAL Samp(1:200) BUFFER      !CREE UN TABLEAU EN MEMOIRE- TAMPON
30 ASSIGN @Dvm TO 722           !AFFECTATION DE L'ADRESSE DU MULTIMETRE
40 ASSIGN @Samp TO BUFFER Samp(*) !AFFECTATION DE LA
45                               !MEMOIRE-TAMPON
50 OUTPUT @Dvm;"PRESET FAST"    !PRECONFIGURATION : TARM SYN,
55                               !TRIG AUTO, FORMATS DINT
60 OUTPUT @Dvm; "MEM FIF0"      !VALIDE LA MEMOIRE DE LECTURE, MODE FIFO
70 OUTPUT @Dvm; "MFORMAT SINT"  !FORMAT DE LA MEMOIRE DE LECTURE: SINT
80 OUTPUT @Dvm; "OFORMAT DREAL" !FORMAT DE SORTIE : REEL LONG
90 OUTPUT @Dvm; "SSDC 10"       !SOUS-ECHANTILLONNAGE, GAMME 10 V,
95                               !COUPLAGE CC
100 OUTPUT @Dvm; "SWEEP 5E - 6,200"!200 ECHANTILLONS, INTERVALLE REEL
105                               !DE 5 µs
110 TRANSFER @Dvm TO @Samp;WAIT !TRANSFERT DES ECHA.??TILLONS DANS LA
115                               !MEMOIRE-TAMPON DU CONTROLEUR
120 FOR I=1 TO 200
130 IF ABS(Samp(I))=1E+38 THEN  !DETECTION D'UNE SURCHARGE
140 PRINT "Overload Occurred"  !IMPRIME UN MESSAGE DE SURCHARGE
150 ELSE                       !EN L'ABSENCE DE SURCHARGE
160 Samp(I)=DROUND(Samp(I),5)  !ARRONDIT A 5 CHIFFRES
170 PRINT Samp(I)              !IMPRIME CHAQUE ECHANTILLON
180 END IF
190 NEXT I
200 END

```

Dans le programme suivant, la commande SSAC est utilisée pour numériser un signal de 10 kHz avec une valeur crête de 5 V. La commande SWEEP demande au multimètre de prendre 1000 échantillons (variable *Num_samples*) avec un *intervalle_réel* de 2 µs (variable *Eff_int*). La mesure utilise le niveau de déclenchement par défaut pour l'événement Source de synchronisation (déclenchement sur le signal d'entrée, 0%, couplage CA, pente positive). La ligne 120 génère un événement SYN et transfère directement les échantillons dans

l'ordinateur. Les lignes 240 à 410 trient les données sous-échantillonnées pour produire le signal composite. Celui-ci est sauvegardé dans le tableau *Wave_form*.

```

10 OPTION BASE 1                !BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Num_samples,Inc,I,J,K,L !DECLARATION DES VARIABLES
30 Num_samples=1000             !NOMBRE D'ECHANTILLONS = 1000
40 Eff_int=2.0E-6               !SPECIFICATION DE L'INTERVALLE REEL
50 INTEGER Int_samp(1:1000) BUFFER !CREE LE TABLEAU DES ENTIERS EN
55                               !MEMOIRE-TAMPON
60 ALLOCATE REAL Wave_form(1:Num_samples) !CREE UN TABLEAU POUR
65                               !LES DONNEES TRIEES
70 ALLOCATE REAL Samp(1:Num_samples) !CREE UN TABLEAU POUR LES
75                               !ECHANTILLONS
80 ASSIGN @Dvm TO 722           !AFFECTATION DE L'ADRESSE DU MULTIMETRE
90 ASSIGN @Int_samp TO BUFFER Int_samp(*) !AFFECTATION DU NOM
95                               !D'ACCES A LA MEMOIRE-TAMPON
100 OUTPUT @Dvm;"PRESET FAST;LEVEL;SLOPE;SSRC LEVEL;SSDC 10"
102 !MESURES RAPIDES, TARM SYN, SOURCE SYNC LEVEL 0V, PENTE
105 !POSITIVE (VALEURS PAR DEFAUT), SOUS-ECHANTILLONNAGE (FORMAT
107 !DE SORTIE SINT) , GAMME 10 V
110 OUTPUT @Dvm;"SWEEP ";Eff_int,Num_samples !INTERVALLE REEL DE
115                               !2 µs, 1000 ECHANTILLONS
120 TRANSFER @Dvm TO @Int_samp;WAIT !EVENEMENT SYNCHRONE, TRANSFERT
121 !DES LECTURES DANS LE TABLEAU DES ENTIERS DE
122 !L'ORDINATEUR; PAS DE CONVERSION DE DONNEES REQUISES PUISQUE
125 !LE FORMAT INTEGER DE L'ORDINATEUR EST IDENTIQUE A SINT (MAIS
127 !TABLEAUX DES ENTIERS REQUIS)
130 OUTPUT @Dvm;"ISCALE?"       !INTERROGATION DU FACTEUR D'ECHELLE POUR
135                               !LE FORMAT SINT
140 ENTER @Dvm; S               !ENTRE LE FACTEUR D'ECHELLE
150 OUTPUT @Dvm;"SSPARM?"       !INTERROGATION DES PARAMETRES DE SOUSE-
155                               !ECHANTILLONNAGE
160 ENTER @Dvm;N1,N2,N3         !ENTRE LES PARAMETRES DE SOUS
165                               !ECHANTILLONNAGE
170 FOR I=1 TO Num_samples
180 Samp(I)=Int_samp(I)         ! CONVERSION DE CHAQUE LECTURE DU FORMAT
185 ! ENTIER AU FORMAT REEL(OBLIGATOIRE POUR EVITER UN

```

```

187 ! DEPASSEMENT ENTIER SUR LA LIGNE SUIVANTE)
190 R=ABS(Samp(I))          !UTILISATION DE LA VALEUR ABSOLUE POUR
195                          !VERIFIER SURCHARGE
200 IF R>=32767 THEN PRINT "OVLD" !SI SURCHARGE, IMPRESSION D'UN
205                          !MESSAGE
210 Samp(I)=Samp(I)*S        !MULTIPLICATION DE LA LECTURE PAR LE
215                          !FACTEUR D'ECHELLE
220 Samp(I)=DROUND(Samp(I),4)!VALEUR ARRONDIE A 4 CHIFFRES
230 NEXT I
235 !-----SORT SAMPLES-----
240 Inc=N1+N2                !NOMBRE TOTAL DE RAFALES
250 K=1
260 FOR I=1 TO N1
270 L=I
280 FOR J=1 TO N3
290 Wave_form(L)=Samp(K)
300 K=K+1
310 L=L+Inc
320 NEXT J
330 NEXT I
340 FOR I=N1+1 TO N1+N2
350 L=I
360 FOR J=1 TO N3-1
370 Wave_form(L)=Samp(K)
380 K=K+ 1
390 L=L+Inc
400 NEXT J
410 NEXT I
420 END

```

SSPARM?

Sub-sampling paramètres query. La commande d'interrogation SSPARM? renvoie les paramètres nécessaires à la reconstitution d'un signal sous-échantillonné (commande SSAC ou SSDC) lorsque les échantillons sont directement envoyés dans la mémoire-tampon de sortie GPIB. (La reconstitution

est automatique lorsque les échantillons sont directement enregistrés en mémoire de lecture).

Le premier paramètre retourné par la commande SSP ARM? est le nombre de “rafales” qui contenait N échantillons. Le second paramètre retourné est le nombre de “rafales” qui contenait N-1 échantillons. Le troisième paramètre retourné est la valeur N. Supposons par exemple que vous sous-échantillonnez un signal de 10 kHz et que vous avez spécifié 22 échantillons séparés par un *intervalle_réel* de 5 s. Dans cet exemple, le multimètre doit utiliser 4 “rafales” au total: 2 de 6 échantillons et 2 de 5 échantillons. Les valeurs retournées par SSPARM? sont 2,2 et 6.

Syntaxe

SSP ARM?

Points importants

- **Commandes connexes:** SSAC, SSDC, SSRC, SWEEP

Exemple

Voir exemple SSDC à la page précédente.

SSRC

Sync source. Source de synchronisation. En mode sous-échantillonnage, (commande SSAC ou SSDC), la commande SSRC vous permet de synchroniser les groupes de lectures sur un signal externe ou sur un niveau de tension du signal d'entrée.

Pour les mesures de tension alternative ou alternative + continue synchrone (commande SETACV SYNC), la commande SSRC vous permet de synchroniser l'échantillonnage sur un signal externe. Vous pouvez également utiliser le paramètre HOLD pour empêcher la méthode de mesure de passer à “aléatoire” lorsque le déclenchement par niveau ne se produit pas dans la limite de temps déterminée par la sélection de la largeur de bande CA (commande ACBAND).

Syntaxe

SSRC [*source*][,*mode*]

source Les valeurs possibles pour le paramètre *source* sont:

Paramètre source	Équivalent numérique	Description
EXT	2	Synchronisation sur une entrée externe appliquée sur le connecteur Ext Trig du panneau arrière
LEVEL ^[a]	7	Synchronisation sur un niveau de tension (commande LEVEL) du signal d'entrée sur la pente spécifiée par la commande SLOPE.

[a] Pour les mesures de tension alternative ou alternative + continue, la tension de déclenchement (commande LEVEL) et la pente (commande SLOPE) sont déterminées automatiquement et ne peuvent pas être spécifiées.

Source à la mise sous tension = LEVEL

Source par défaut = LEVEL

mode Le paramètre mode ne s'applique qu'aux mesures ACV ou ACDCV synchrones. Les choix possibles sont:

Paramètre mode	Équivalent numérique	Description
AUTO ^[a]	1	Pour les mesures de tension alternative ou alternative + continue synchrone (SETACV SYNC) utilisant le déclenchement par niveau (mode par défaut), si le signal d'entrée est supprimé pendant une lecture et ne revient pas au bout d'un certain laps de temps, la méthode de mesure passe de synchrone à aléatoire pour que la lecture puisse se terminer. (Après la lecture, la méthode de mesure revient à SYNC)
HOLD	4	La méthode de mesure spécifiée ne passera pas automatiquement de synchrone à aléatoire lorsque le signal d'entrée est supprimé.

[a] La limite de temps pour les mesures AC ou ACDCV synchrones est déterminée par la largeur de bande spécifiée par la commande ACBAND.

Mode à la mise sous tension = AUTO

Mode par défaut = AUTO

Points importants

- Pour le sous-échantillonnage, l'événement de déclenchement et l'événement d'échantillonnage sont ignorés. Les seuls événements qui s'appliquent au sous-échantillonnage sont l'armement de déclenchement (commande TARM) et la source de synchronisation (commande SSRC). Pour les mesures de tensions alternative ou alternative + continue synchrones (commande SETACV SYNC), l'événement d'armement de déclenchement spécifié (commande TARM) et l'événement d'échantillonnage (commande NRDGS) doivent tous deux être satisfaits pour que l'événement Source de synchronisation puisse initialiser l'échantillonnage.
- Pour le sous-échantillonnage et les mesures alternatives synchrones, les groupes d'échantillons sont pris sur plusieurs périodes du signal. L'événement Source de synchronisation synchronise les groupes d'échantillons sur les périodes du signal d'entrée (en d'autres termes, un événement Source de synchronisation doit typiquement se produire une fois pour chaque période).
- **Commande d'interrogation:** La commande d'interrogation SSRC? renvoie deux réponses, séparées par une virgule. La première réponse est la source courante. La seconde réponse est le mode courant. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** LEVEL, LFILTER, SETACV SYNC, SLOPE, SSAC, SSDC

Exemples

Dans le programme suivant, la commande SSAC est utilisée pour numériser un signal de 10 kHz avec une valeur crête de 5 V. La commande SWEEP demande au multimètre de prendre 1000 échantillons (variable Num_samples) avec un *intervalle_réel* de 2 μ s (variable Eff_int). La mesure utilise le niveau de déclenchement par défaut pour l'événement Source de synchronisation (déclenchement sur le signal d'entrée, 0%, couplage CA, pente positive). La ligne 120 génère un événement SYN et transfère directement les échantillons dans l'ordinateur. Les lignes 240 à 410 trient les données sous-échantillonnées pour produire le signal composite. Celui-ci est sauvegardé dans le tableau Wave_form.

```

10 OPTION BASE 1                !BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Num_samples,Inc,I,J,K,L !DECLARATION DES VARIABLES
30 Num_samples=1000             !NOMBRE D'ECHANTILLONS = 1000
40 Eff_int=2.0E-6               !SPECIFICATION DE L' INTERVALLE_REEL
50 INTEGER Int_samp(1:1000) BUFFER !CREE LE TABLEAU DES ENTIERS EN

```

```

55                                !MEMOIRE-TAMPON
60 ALLOCATE REAL Wave_form(1:Num_samples)!CREE UN TABLEAU POUR
65                                !LES DONNEES TRIEES
70 DATA ALLOCATE REAL Samp(1:Num_samples)!CREE UN TABLEAU POUR LES
75                                !ECHANTILLONS
80 ASSIGN @Dvm TO 722            !AFFECTATION DE L'ADRESSE DU MULTIMETRE
90 ASSIGN @Int_samp TO BUFFER Int_samp(*)!AFFECTATION DU NOM
95                                !D'ACCES A LA MEMOIRE-TAMPON
100 OUTPUT @Dvm;"PRESET FAST;LEVEL;SLOPE;SSRC LEVEL;SSDC 10"
102 !MESURES RAPIDES, TARM SYN, SOURCE SYNC LEVEL 0V, PENTE
105 !POSITIVE (VALEURS PAR DEFAUT), SOUS-ECHANTILLONNAGE (FORMAT
107 !DE SORTIE SINT), GAMME 10 V
110 OUTPUT @Dvm;"SWEEP ";Eff_int,Num_samples !INTERVALLE REEL DE
115                                !2 µs, 1000 ECHANTILLONS
120 TRANSFER @Dvm TO @Int_samp;WAIT !EVENEMENT SYNCHRONE,
121 !TRANSFERT DES LECTURES DANS LE TABLEAU DES ENTIERS DE
122 !L'ORDINATEUR; PAS DE CONVERSION DE DONNEES REQUISES PUISQUE
125 !LE FORMAT INTEGER DE L'ORDINATEUR EST IDENTIQUE A SINT (MAIS
127 !TABLEAUX DES ENTIERS REQUIS)
130 OUTPUT @Dvm;"ISCALE?"        !INTERROGATION DU FACTEUR D'ECHELLE POUR
135                                !LE FORMAT SINT
140 ENTER @Dvm; S                !ENTRE LE FACTEUR D'ECHELLE
150 OUTPUT @Dvm;"SSPARM?"        !INTERROGATION DES PARAMETRES DE SOUS
155                                !ECHANTILLONNAGE
160 ENTER @Dvm;N1,N2,N3          !ENTRE LES PARAMETRES DE SOUS
165                                !ECHANTILLONNAGE
170 FOR I=1 TO Num_samples
180 Samp(I)=Int_samp(I)          !CONVERSION DE CHAQUE LECTURE DU FORMAT
185 !ENTIER AU FORMAT REELCOBLIGATOIRE POUR EVITER UN
187 !DEPASSEMENT ENTIER SUR LA LIGNE SUIVANTE)
190 R=ABS(Samp(I))               !UTILISATION DE LA VALEUR ABSOLUE POUR
195                                !VERIFIER SURCHARGE
200 IF R>=32767 THEN PRINT "OVL" !SI SURCHARGE, IMPRESSION D'UN
205                                !MESSAGE
210 Samp(I)=Samp(I)*S            !MULTIPLICATION DE LA LECTURE PAR LE
215                                !FACTEUR D'ECHELLE
220 Samp(I)=DROUND(Samp(I),4)!VALEUR ARRONDIE A 4 CHIFFRES

```

```

230 NEXT I
235 !-----TRI DES ECHANTILLONS-----
240 Inc=N1+N2          !NOMBRE TOTAL DE RAFALES
250 K=1
260 FOR I=1 TO N1
270 L=1
280 FOR J=1 TO N3
290 Wave_form(L)=Samp(K)
300 K=K+1
310 L=L+Inc
320 NEXT J
330 NEXT I
340 FOR I=N1+1 TO N1+N2
350 L=I
360 FOR J=1 TO N3-1
370 Wave_form(L)=Samp(K)
380 K=K+ 1
390 L=L+Inc
400 NEXT J
410 NEXT I
420 END

```

Dans le programme suivant, l'événement SSRC EXT est utilisé avec les mesures de tension. alternative synchrones. Dès que l'événement de déclenchement se produit (les événements d'armement de déclenchement et d'échantillonnage sont à AUTO), la première transition TTL, négative sur le connecteur **Ext Trig** initialise le premier groupe de lectures. Chaque déclenchement externe suivant initialise un groupe de lectures jusqu'à ce que le nombre de groupes spécifié ait été atteint.

```

10 OUTPUT 722;"PRESET NORM"    !PRECONFIGURATION : TARM AUTO, TRIG SYN,
15                             !NRDGS 1,AUTO
20 OUTPUT 722;"ACV 10"        !TENSION ALTERNATIVE, GAMME 10 V
30 OUTPUT 722;"SETACV SYNC"    !METHODE DE MESURE SYNCHRONE
40 OUTPUT 722;"SSRC EXT"       !SOURCE DE SYNCHRONISATION EXTERNE
50 ENTER 722;A                !DECLENCHE LES LECTURES (TRIG SYN),
55                             !ENTRE LA LECTURE

```



```
60 PRINT A
70 END
```

!IMPRIME LA LECTURE

SSTATE

Store state. La commande SSTATE sauvegarde l'état courant du multimètre et lui affecte un nom. Les états enregistrés peuvent ensuite être rappelés à l'aide de la commande RSTATE.

Syntaxe

SSTATE *nom*

nom Nom de l'état. Le nom d'un état peut comporter 10 caractères (alphabétiques ou alphanumériques) maximum. Vous pouvez également utiliser un entier compris entre 0 et 127 comme nom d'état. Le premier caractère d'un nom alphanumérique doit toujours être alphabétique. Aucun nom d'état (alphabétique ou alphanumérique) ne doit être identique à une commande ou à un paramètre du multimètre ni à un sous-programme sauvegardé. Les caractères ? et _ sont également acceptés.

Lorsque vous utilisez un entier comme nom d'état, le multimètre lui affecte le préfixe ST A TE lorsqu'il le sauvegarde pour pouvoir le différencier d'un sous-programme dont le nom serait également un entier. Un état enregistré sous le nom 8 par exemple sera sauvegardé sous le nom ST A TE8. Pour rappeler cet état, vous pouvez utiliser le nom 8 ou ST A TE8. Le nom ST A TEO est réservé à l'état de mise hors tension du multimètre (voir premier point important, ci-dessous).

Nom à la mise sous tension= aucun

Nom par défaut= aucun; paramètre obligatoire

Points importants

- En cas de coupure secteur, le multimètre sauvegarde sa configuration courante sous l'état O. Après une coupure secteur, le multimètre peut être configuré à son précédent état en exécutant la commande RSTATE O.
- Tous les états sont enregistrés en mémoire permanente (ils ne sont pas effacés à la mise hors tension de l'instrument).

- Les sous-programmes, le contenu de la mémoire de lecture, les touches définies par l'utilisateur et le mode MENU du panneau avant ne sont pas sauvegardés dans l'état. Le contenu des registres mathématiques suivants sont sauvegardés en même temps que l'état (tous les autres registres mathématiques sont configurés à 0):

DEGREE	REF
LOWER	RES
OFFSET	SCALE
PERC	UPPER

- Le multimètre dispose de 14 Ko de mémoire d'état. Chaque état occupe environ 300 octets, ce qui permet de sauvegarder un maximum de 46 états. L'état 0 est réservé à la sauvegarde de l'état du multimètre lorsqu'il est mis hors tension. Vous pouvez cependant utiliser STATE 0 pour sauvegarder d'autres états, mais ceux-ci seront remplacés par l'état de mise hors tension du multimètre en cas de coupure d'alimentation secteur.
- Vous pouvez visualiser le nom de tous les états enregistrés à partir du panneau avant en appuyant sur la touche RST A TE et sur une touche fléchée (vers le haut ou vers le bas). Dès que le nom de l'état recherché s'affiche, appuyez sur Enter pour le rappeler.
- **Commandes connexes:** MSIZE, PURGE, RSTATE, SCRATCH

Exemple

```
OUTPUT 722;"SSTATE B2" !SAUVEGARDE L'ETAT COURANT DU MULTIMETRE
!SOUS LE NOM B2
```

STB?

Status byte query. Le registre d'état contient huit bits qui surveillent diverses conditions du 3458A. En cas d'occurrence d'une de ces conditions, le bit correspondant est positionné dans le registre d'état. La commande STB? (status byte? octet d'état ?) renvoie un nombre représentant les bits positionnés. Le nombre renvoyé est la somme pondérée de tous les bits positionnés.

Syntaxe

STB?

Conditions du registre d'état

Les conditions du registre d'état et les valeurs correspondantes sont:

Valeur pondérée	Numéro de bit	Condition du registre d'état
1	0	Exécution de la mémoire de programme terminée
2	1	Limite Haute ou Basse dépassée
4	2	Exécution de la commande SRQ
8	3	Mise sous tension
16	4	Prêt pour instructions
32	5	Erreur {Consulter le registre d'erreur}
64	6	Service demandé {vous ne pouvez invalider ce bit}
128	7	Données disponibles

Points importants

- Pendant l'exécution de la commande STB?, le bit prêt (bit 4) est toujours à zéro (non prêt) puisque le 3458A traite la commande STB?.
- La commande CSB efface le registre d'état (les bits 4, 5 et 6 ne sont pas remis à 0 si la condition qui les positionne existe toujours). La commande RQS désigne quelles conditions du registre d'état valideront un SRQ sur le bus GPIB.
- **Commandes connexes:** CSB, EXTOUT, RQS, SPOLL (commande GPIB)

Exemple

```

10 OUTPUT 722;"STB?" !RETOURNE LA SOMME PONDEREE DES BITS
15                      !POSITIONNES
20 ENTER 722          !ENTRE LA REPONSE DANS LA VARIABLE A
30 PRINT A            !IMPRIME LA RESPONSE
40 END

```

Si par exemple le programme ci-dessus renvoie la somme pondérée 24, cela signifie que les bits avec les valeurs pondérées 8 (mise sous tension) et 16 (prêt pour instructions) sont positionnés.

SUB

Subprogram. La commande SUB permet d'enregistrer une série de commandes comme un sous-programme et de lui affecter un nom permettant de l'identifier.

Syntaxe

SUB *nom*

nom Nom du sous-programme. Le nom d'un sous-programme peut comporter 10 caractères (alphabétiques ou alphanumériques) maximum. Vous pouvez également utiliser un entier compris entre 0 et 127 comme nom de sous-programme. Le premier caractère d'un nom alphanumérique doit toujours être alphabétique. Aucun nom de sous-programme (alphabétique ou alphanumérique) ne doit être identique à une commande ou à un paramètre du multimètre ni à un état sauvegardé. Les caractères ? et _ sont également acceptés.

Lorsque vous utilisez un entier (0-127) comme nom de sous-programme, le multimètre lui affecte le préfixe SUB lorsqu'il le sauvegarde pour pouvoir le différencier d'un état dont le nom serait également un entier. Un sous-programme enregistré sous le nom 15 par exemple sera sauvegardé sous le nom SUB15. Pour rappeler ce sous-programme, vous pouvez utiliser le nom 15 ou SUB15. Le sous-programme 0 (zéro) correspond à un sous-programme de démarrage automatique (voir point 7 ci-dessous).

Nom à la mise sous tension = aucun

Nom par défaut = aucun; paramètre obligatoire

Points importants

- La fin d'un sous-programme doit être indiquée avec la commande SUBEND. La commande CALL sert à exécuter un sous-programme et les commandes PAUSE et CONT à interrompre et à reprendre l'exécution d'un sous-programme, respectivement.
- Si vous sauvegardez un nouveau sous-programme sous le nom d'un sous-programme déjà existant, le nouveau sous-programme écrasera (remplacera) l'ancien.
- L'entrée (la sauvegarde) d'un sous-programme à partir du panneau avant n'est pas recommandée dans la mesure où les utilitaires du panneau avant (touches vers le haut ou vers le bas par exemple) risquent d'être accidentellement sauvegardés dans le sous-programme. Une fois que vous avez exécuté la commande SUB à partir du panneau avant, l'affichage indique SUB ENTRY MODE jusqu'à ce que la commande SUBEND soit exécutée ou la touche RESET enfoncée. La commande SUBEND n'apparaît sur le menu du panneau avant que lorsque vous sauvegardez un sous-programme.
- Si une commande SCRATCH, DELSUB, une seconde commande SUB ou la commande GPIB Device Clear survient dans un sous-programme, le multimètre ne sauvegarde pas la commande mais sauvegarde cependant le reste du sous-programme. En cas de RESET, l'exécution du sous-programme est interrompue (n'enregistrez pas de commande RESET dans un sous-programme).
- Vous ne pouvez mémoriser un sous-programme avec une capacité mémoire de sous-programme/état inférieure à 800 octets.
- L'exécution du sous-programme sera également interrompue en cas de détection d'une erreur ou à réception d'une commande GPIB Device Clear. Cette dernière commande interrompra en même temps la sauvegarde en cours d'un sous-programme.
- La seule manière d'effectuer des lectures à l'intérieur d'un sous-programme consiste à utiliser la commande TARM SGL ou TRIG SGL. Lorsque le multimètre rencontre l'une ou l'autre de ces commandes, il n'exécute pas la commande suivante du sous-programme tant que toutes les lectures spécifiées n'ont pas été effectuées. (Cela signifie que toutes les commandes de configuration et les autres commandes de déclenchement doivent être exécutées avant la commande TARM SGL ou TRIG SGL). Tout autre événement d'armement ou de déclenchement (à l'exception de TARM EXT, voir remarque

suivante) s'exécutera dans un sous-programme mais les lectures ne seront pas initialisées tant que l'exécution du sous-programme ne sera pas terminée.

- Quand le multimètre rencontre une commande TARM EXT dans un sous-programme, il attend de recevoir un déclenchement externe sur son connecteur **Ext Trig** avant d'exécuter la ligne suivante du sous-programme. Ceci vous permet de synchroniser l'exécution d'un sous-programme sur un appareil externe.
- Tout sous-programme portant le nom O s'exécutera automatiquement à chaque fois que le multimètre aura terminé sa séquence de mise sous tension. Après une coupure secteur, vous pouvez ainsi rappeler l'état du multimètre à l'aide de la commande RSTATE O.
- **Commandes connexes:** CALL, COMPRESS, CONT, DELSUB, PAUSE, SCRATCH, SUBEND

Exemples

```

10 OPTION BASE 1                !LIMITE INFERIEURE DU TABLEAU A 1
20 DIM RDGS(5)                  !DIMENSIONNE LE TABLEAU POUR 5 LECTURES
30 OUTPUT 722;"SUB DCCUR2"      !ENREGISTRE LES LIGNES SUIVANTES SOUS LE
35                               !NOM DDCUR2
40 OUTPUT 722;"PRESET NORM"     !PRECONFIGURE LE MULTIMETRE
50 OUTPUT 722;"MEM FIFO"        !VALIDE LE MODE FIFO DE LA MEMOIRE DE
55                               !LECTURE
60 OUTPUT 722;"DCV, 10, .01"    !TENSION CONTINUE, GAMME 10V,
65                               !RESOLUTION 0,01%
70 OUTPUT 722;"NRDGS,5,AUTO"    !5 LECTURES/DECLenchement,
75                               !EVENEMENT AUTO
80 OUTPUT 722;"TRIG SGL"        !MODE DE DECLenchement UNIQUE
90 OUTPUT 722;"SUBEND"          !SIGNALA LA FIN D'UN SS-PROGRAMME
100 OUTPUT 722;"DISP MSG 'CALLING SUBPROGRAM'"
110 OUTPUT 722;"CALL DCCUR2"
120 ENTER 722;Rdgs(*)
130 PRINT Rdgs(*)
140 END

```

Lorsque le programme suivant est appelé (CALL EXTPACE), le multimètre l'exécute ligne par ligne jusqu'à ce qu'il rencontre la commande TARM EXT (ligne 70). L'exécution du sous-programme s'interrompt alors jusqu'à ce qu'un déclenchement externe se produise. A réception du premier déclenchement externe, l'exécution du sous-programme reprend. A la ligne suivante (TRIG SGL), l'exécution du sous-programme s'interrompt à nouveau jusqu'à ce que 1000 lectures soient effectuées. Après les lectures, le sous-programme change la fonction en mesure de résistance 2-fils et le nombre de lectures (100). Lorsque le multimètre rencontre la seconde commande TARM EXT (ligne 100), l'exécution du sous-programme s'interrompt jusqu'à ce qu'un autre déclenchement externe se produise. Une fois le déclenchement externe reçu, la commande TRIG SGL suspend l'exécution du sous-programme jusqu'à ce que 100 lectures soient effectuées. Après les lectures, le message TEST FINISHED (TEST TERMINE) s'affiche.

```

10 OUTPUT 722; "SUB EXTPACE"  !ENREGISTRE LES LIGNES 20-110 COMME UN
15                               !SOUS-PROGRAMME
20 OUTPUT 722; "PRESET NORM"  !PRECONFIGURE LE MULTIMETRE, SUSPEND LES
25                               !LECTURES
30 OUTPUT 722; "MEM FIFO"     !VALIDE LE MODE FIFO DE LA MEMOIRE DE
35                               !LECTURE
40 OUTPUT 722; "DCV 10"       !MESURES DE TENSION CONTINUE, GAMME 10V
50 OUTPUT 722; "NRDGS 1000, AUTO" !1000 LECTURES/DECLenchement,
55                               !EVENEMENT D'ECHANTILLONNAGE AUTO
60 OUTPUT 722; "TARM EXT"     !EVENEMENT D'ARMEMENT DE DECLenchement
65                               !EXTERNE
70 OUTPUT 722; "TRIG SGL"     !MODE DE DECLenchement UNIQUE
80 OUTPUT 722; "OHM 1E3"      !RESISTANCE 2-FILS, GAMME 1 kΩ
90 OUTPUT 722; "NRDGS 100, AUTO" !100 LECTURES/DECLenchement,EVENEMENT
95                               !D'ECHANTILLONNAGE AUTO
100 OUTPUT 722;"TARM EXT"     !EVENEMENT D'ARMEMENT DE DECLenchement
105                               !EXTERNE
110 OUTPUT 722;"TRIG SGL"     !MODE DE DECLenchement UNIQUE
120 OUTPUT 722;"DISP MSG,'TEST FINISHED'" !INDIQUE QUE LE SOUS-
125                               !PROGRAMME A TERMINE
130 OUTPUT 722;"SUBEND"
140 END

```

SUBEND

Subprogram end. La commande SUBEND signale la fin d'un sous-programme.

Syntaxe

SUBEND

Points importants

- Lorsque vous enregistrez un sous-programme. SUBEND indique la fin du sous-programme. Lorsqu'un sous-programme a été exécuté, SUBEND positionne le bit 1 (s'il est validé) dans le registre d'état qui indique que l'exécution du sous-programme est terminée.
- **Commandes connexes:** CALL, COMPRESS, CONT, DELSUB, PAUSE, SCRATCH, SUB

Exemple

Voir exemple SUB à la page précédente.

SWEEP

La commande SWEEP spécifie l'intervalle_réel entre les échantillons (lectures) et le nombre total d'échantillons par déclenchement (pour la plupart des fonctions de mesure) ou par événement d'armement de déclenchement (sous-échantillonnage uniquement).

Syntaxe

SWEEP [*intervalle_réel*] [,#_échantillons]

intervalle_réel En sous-échantillonnage (SSAC ou SSDC), ce paramètre spécifie l'espacement des échantillons dans le signal reconstitué (voir [chapitre 5](#)). Pour toutes les autres fonctions de mesure, ce paramètre spécifie l'intervalle de temps réel entre un échantillon et le suivant. En sous-échantillonnage, la gamme de ce paramètre peut varier entre 10E-9 à 6000 secondes; pour toutes les autres fonctions de mesure, la gamme va de 1/vitesse de lecture maximale à 6000 secondes.

Intervalle_réel a la mise sous tension = 100E-9

Intervalle_réel par défaut = 20 µs

#_échantillons Spécifie le nombre d'échantillons à prendre. La gamme de ce paramètre va de 1 à 1.67E+7.

#_échantillons à la mise sous tension = 1024

#_échantillons par défaut = 1024

Points importants

- L'intervalle_réel minimal pour les mesures de tension continue est de 10 µs; pour l'échantillonnage direct, il est de 20 µs et pour le sous-échantillonnage de 10 nanosecondes.
- La commande SWEEP peut être utilisée en remplacement des commandes NRDGS *n*, TIMER et TIMER. Les commandes SWEEP et NRDGS sont interchangeables et le multimètre utilisera celle qui aura été exécutée en dernier. L'exécution de la commande SWEEP définit automatiquement l'événement d'échantillonnage à TIMER. Dans les états de mise sous tension, RESET ou PRESET, le multimètre utilise la commande NRDGS. Les valeurs de mise sous tension de SWEEP ne peuvent être spécifiées qu'en sous-échantillonnage (dans la mesure ou ce mode de mesure n'accepte pas la commande NRDGS).
- Vous ne pouvez pas utiliser les fonctions SWEEP ou TIMER pour les mesures de tension alternative ou alternative + continue utilisant les méthodes synchrone ou aléatoire (SETACV SYNC ou RNDM) ni pour les mesures de fréquence ou de période.
- Si vous utilisez la commande SWEEP (ou l'événement TIMER), la fonction de changement de gamme automatique est suspendue (typiquement, vous sélectionnez une gamme fixe dans la commande SWEEP).
- **Commande d'interrogation:** La commande d'interrogation SWEEP? renvoie deux réponses, séparées par une virgule. La première réponse indique *l'intervalle_réel* spécifié; la seconde, le *#_échantillons* spécifié. Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes:** FUNC, NRDGS, TIMER

Exemple

Dans le programme suivant, la commande SSAC est utilisée pour numériser un signal de 10 kHz avec une valeur crête de 5 V. La commande SWEEP demande au multimètre de prendre 1000 échantillons (variable Num_samples) avec un

intervalle_réel de 2 μ s (variable Eff_int). La mesure utilise le niveau de déclenchement par défaut pour l'événement Source de synchronisation (déclenchement sur le signal d'entrée, 0%, couplage CA, pente positive).

La ligne 120 génère un événement SYN et transfère directement les échantillons dans l'ordinateur. Les lignes 240 à 410 trient les données sous-échantillonnées pour produire le signal composite. Celui-ci est sauvegardé dans le tableau Wave_form.

```

10 OPTION BASE 1                !BORNE INFERIEURE DU TABLEAU A 1
20 INTEGER Num_samples,Inc,I,J,K,L !DECLARATION DES VARIABLES
30 Num_samples=1000             !NOMBRE D'ECHANTILLONS = 1000
40 Eff_int=2.0E-6               !SPECIFICATION DE L' INTERVALLE_REEL
50 INTEGER Int_samp(1:1000) BUFFER !CREE LE TABLEAU DES ENTIERS EN
55                               !MEMOIRE-TAMPON
60 ALLOCATE REAL Wave_form(1:Num_samples) !CREE UN TABLEAU POUR LES
65                               !DONNEES TRIEES
70 ALLOCATE REAL Samp(1:Num_samples) !CREE UN TABLEAU POUR LES
75                               !ECHANTILLONS
80 ASSIGN @Dvm TO 722           !AFFECTATION DE L'ADRESSE DU MULTIMETRE
90 ASSIGN @Int_samp TO BUFFER Int_samp(*) !AFFECTATION DU NOM
95                               !D'ACCES A LA MEMOIRE-TAMPON
100 OUTPUT @Dvm;"PRESET FAST;LEVEL;SLOPE;SSRC LEVEL;SSDC 10"
102 !MESURES RAPIDES, TARM SYN, SOURCE SYNC LEVEL 0V, PENTE
105 !POSITIVE (VALEURS PAR DEFAUT), SOUS-ECHANTILLONNAGE (FORMAT
107 !DE SORTIE SINT), GAMME 10 V
110 OUTPUT @Dvm;"SWEEP ";Eff_int,Num_samples !INTERVALLE REEL DE
115 !2μs, 1000 ECHANTILLONS
120 TRANSFER @Dvm TO @Int_samp;WAIT !EVENEMENT SYNCHRONE, TRANSFERT
121 !DES LECTURES DANS LE TABLEAU DES ENTIERS DE L'ORDINATEUR; PAS DE
122 !CONVERSION DE DONNEES REQUISES PUISQUE LE FORMAT INTEGER DE
125 !L'ORDINATEUR EST IDENTIQUE A SINT (MAIS TABLEAUX DES ENTIERS
127 !REQUIS)
130 OUTPUT @Dvm;"ISCALE?"       !INTERROGATION DU FACTEUR D'ECHELLE POUR
135                               !LE FORMAT SINT
140 ENTER @Dvm; S               !ENTRE LE FACTEUR D'ECHELLE
150 OUTPUT @Dvm;"SSPARM?"       !INTERROGATION DES PARAMETRES DE SOUS-
155                               !ECHANTILLONNAGE

```

```

160 ENTER @Dvm;N1,N2,N3      !ENTRE LES PARAMETRES DE SOUS-
165                          !ECHANTILLONNAGE
170 FOR I=1 TO Num_samples
180 Samp(I)=Int_samp(I)      !CONVERSION DE CHAQUE LECTURE DU FORMAT
185 !ENTIER AU FORMAT REEL(OBLIGATOIRE POUR EVITER UN
187 !DEPASSEMENT ENTIER SUR LA LIGNE SUIVANTE)
190 R=ABS(Samp(I))           !UTILISATION DE LA VALEUR ABSOLUE POUR
195                          !VERIFIER SURCHARGE
200 IF R>=32767 THEN PRINT "OVLD" !SI SURCHARGE, IMPRESSION D'UN
205                          !MESSAGE
210 Samp(I)=Samp(I)*S        !MULTIPLICATION DE LA LECTURE PAR LE
215                          !FACTEUR D'ECHELLE
220 Samp(I)=DROUND(Samp(I),4) !VALEUR ARRONDIE A 4 CHIFFRES
230 NEXT I
235 !-----TRI DES ECHANTILLONS-----
240 Inc=N1+N2                !NOMBRE TOTAL DE RAFALES
250 K=1
260 FOR I=1 TO N1
270 L=1
280 FOR J=1 TO N3
290 Wave_form(L)=Samp(K)
300 K=K+1
310 L=L+Inc
320 NEXT J
330 NEXT I
340 FOR I=N1+1 TO N1+N2
350 L=I
360 FOR J=1 TO N3-1
370 Wave_form(L)=Samp(K)
380 K=K+1
390 L=L+Inc
400 NEXT J
410 NEXT I
420 END

```

T

La commande Test une abréviation de la commande TRIG.

Syntaxe

T [événement]

Pour plus de détails, voir commande TRIG.

TARM

Trigger arm. La commande TARM (trigger arm armement de déclenchement) définit l'événement qui valide (arme) l'événement de déclenchement spécifié (commande TRIG). Vous pouvez également utiliser cette commande pour effectuer de multiples cycles de mesure

Syntaxe

TARM [événement][,nombre d'armement]

événement Les valeurs possibles du paramètre *événement* sont:

Paramètre événement	Équivalent numérique	Description
AUTO	1	Toujours armé
EXT	2	Armé sur transition TTL négative sur le connecteur EXT TRIG. (L'exécution de TARM EXT efface la mémoire tampon de déclenchement si TBUFF est ON).
SGL	3	Armé une fois (à la réception d'un TARM SGL) puis HOLD
HOLD	4	Déclenchement invalidé
SYN	5	Armé quand la mémoire tampon de sortie du 3458A est vide, la mémoire de lecture vide ou inactivée, et que le contrôleur attend des données du 3458A.

événement à la mise sous tension = AUTO.

événement par défaut= AUTO.

nombre_d'armements Le paramètre *nombre_d'armements* ne peut être utilisé qu'avec l'événement d'armement de déclenchement SGL. Dans ce cas, vous spécifiez le nombre d'armements par un nombre compris entre 0 et 2.1E+9. Spécifier 0 ou 1 avec l'événement SGL revient à utiliser la valeur par défaut (1): le déclenchement est armé une fois puis repasse à HOLD (invalidé). Quand vous spécifiez un nombre supérieur à 1, vous sélectionnez un "armement multiple". Dans l'armement multiple, le multimètre génère autant d'armements de déclenchement que nécessaire pour satisfaire le paramètre *nombre_d'armements*. Pour plus de détails sur le principe d'armement multiple, voir les points importants, ci-après.

Nombre_d'armements à la mise sous tension= 1 (armement multiple invalidé)

Nombre_d'armements par défaut= 1 (armement multiple invalidé)

Points importants

-
- Pour toutes les fonctions de mesure excepté le sous-échantillonnage (voir [chapitre 5](#)), l'événement d'armement de déclenchement opère avec l'événement de déclenchement (commande TRIG) et l'événement d'échantillonnage (commande NRDGS ou SWEEP). Pour effectuer une mesure, l'événement d'armement doit avoir lieu, suivi de l'événement de déclenchement, et finalement de l'événement d'échantillonnage.
- L'événement d'armement de déclenchement n'initialise pas nécessairement un déclenchement. Il ne fait que le permettre. Référez-vous à [Déclenchement des mesures](#) au [chapitre 4](#) pour une discussion approfondie de l'interaction des divers événements.
- Armement multiple: Quand vous utilisez l'armement multiple, l'événement d'armement de déclenchement doit être spécifié par SGL. Quand le 3458A exécute une commande TARM spécifiant un armement multiple, il conserve le bus GPIB jusqu'à ce que tous les cycles de mesure soient terminés. Par exemple, si vous prenez 5 comme nombre d'armements, et 10 lectures par cycle (commande NRDGS), il y a 5 cycles de mesure de 10 lectures chacun. Comme elle conserve le bus, la commande TARM doit être la dernière ligne dans le programme et vous ne pouvez utiliser l'événement de déclenchement synchrone ou l'événement d'échantillonnage.
- **Commande d'interrogation:** La commande d'interrogation TARM? renvoie l'événement d'armement de déclenchement couramment sélectionné. Pour

plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.

- **Commandes connexes:** NRDGS, SWEEP, TRIG

Exemples

```

OUTPUT 722; "TARM AUTO, 0"      !ARME AUTOMATIQUEMENT LE DECLENCHEMENT
                                !(TOUJOURS ARME)

10 OUTPUT 722; "TARM HOLD"      !INTERROMPT LES MESURES
20 OUTPUT 722; "OHM"            !MESURES DE RESISTANCES 2-FILS
30 OUTPUT 722; "MEM FIFO"       !VALIDE LA MEMOIRE DE LECTURE, MODE FIFO
40 OUTPUT 722; "NRDGS 5"        !5 LECTURES PAR EVENEMENT
45                               !D'ECHANTILLONNAGE (AUTO)
50 OUTPUT 722; "TARM SGL"       !VALIDE UNE SERIE DE MESURES
60 END

10 OUTPUT 722; "DCV"            !MESURES DE TENSION CONTINUE
20 OUTPUT 722; "TARM HOLD"      !INTERROMPT LES MESURES
30 OUTPUT 722; "TRIG AUTO"      !AUTO COMME EVENEMENT DE DECLENCHEMENT
40 OUTPUT 722; "MEM FIFO"       !VALIDE LA MEMOIRE DE LECTURE, MODE FIFO
50 OUTPUT 722; "NRDGS 3, AUTO"  !3 LECTURES PAR EVENEMENT
55                               !D'ECHANTILLONNAGE (AUTO)
60 OUTPUT 722; "TARM SGL,5"     !ARMEMENT MULTIPLE POUR 5 CYCLES
70 END

```

Dans ce programme, la ligne 60 arme le déclenchement une fois pour chaque cycle de mesure. Cela a lieu cinq fois. Après le cinquième cycle, l'armement de déclenchement revient à HOLD. Ce programme place 15 lectures (3 lectures par événement de déclenchement, 5 fois) dans la mémoire de lecture.

A moins que la mémoire tampon d'entrée ne soit validée, à la ligne 60, le 3458A conserve le bus jusqu'à ce que tous les cycles de mesure soient terminés. Si vous voulez reprendre immédiatement le contrôle du bus, supprimez le *cr lf* en remplaçant la ligne 60 par:

```
60 OUTPUT 722 USING "#,K" TARM SGL, 5;"
```

Dans la ligne ci-dessus, le spécificateur d'image # supprime le *cr lf*. Le spécificateur d'image K supprime les blancs de fin ou de tête et envoie la

commande en format libre. Remarquez le point-virgule après TARM SGL,5. Il indique la fin de la commande au 3458A et doit être présent si vous supprimez *cr lf*.

TBUFF

Trigger buffer. La commande TBUFF valide ou invalide la mémoire-tampon de déclenchement externe du multimètre.

Syntaxe

TBUFF [*contrôle*]

contrôle Les valeurs possibles du paramètre *contrôle* sont:

Paramètre <i>control</i>	Équivalent numérique	Description
OFF	0	Invalide la mémoire-tampon de déclenchement et valide l'erreur TRIGGER TOO FAST
ON	1	Valide et efface la mémoire-tampon de déclenchement et invalide l'erreur TRIGGER TOO FAST

Contrôle à la mise sous tension = OFF.

Contrôle par défaut = OFF.

Points importants

- La validation de la mémoire-tampon de déclenchement (TBUFF ON) corrige l'erreur TRIGGER TOO FAST susceptible de se produire avec un événement d'armement, de déclenchement ou d'échantillonnage externe. Lorsque la mémoire-tampon de déclenchement est invalidée (TBUFF OFF), tout déclenchement externe survenant pendant une lecture génère l'erreur TRIGGER TOO FAST (Déclenchement trop rapide) et le ou les déclenchements sont ignorés. Lorsque TBUFF est ON (validé), le premier déclenchement externe survenant pendant une lecture est enregistré et aucune erreur n'est générée par ce déclenchement ou les déclenchements suivants. Une fois la lecture terminée, le déclenchement enregistré satisfait l'événement EXT si le multimètre a été programmé sur des événements externes.

- L'exécution de la commande RESET configure TBUFF sur OFF.
- **Commande d'interrogation**: La commande d'interrogation TBUFF? renvoie le mode de la mémoire-tampon de déclenchement Pour plus de détails sur les **Commandes d'interrogation**, se reporter au début du présent chapitre.
- **Commandes connexes**: EXTOUT, NRDGS, TRIG

Exemple

```
OUTPUT 722;"TBUFF ON" !INVALIDE L'ERREUR DE DECLENCHEMENT TROP
                        !RAPIDE
```

TEMP?

Temperature query. La commande d'interrogation TEMP? renvoie la température interne du multimètre en degrés Celsius.

Syntaxe

TEMP?

Points importants

- Il est intéressant de surveiller régulièrement la température du multimètre pour déterminer la fréquence des étalonnages automatiques.
- **Commandes connexes**: ACAL, CAL, CALSTR

Exemple

```
10 OUTPUT 722; "TEMP?" !LIT LA TEMPERATURE
20 ENTER 722; A        !ENTRE LE RESULTAT
30 PRINT A             !IMPRIME LE RESULTAT
40 END
```


TERM

Dans les précédents multimètres Keysight, la commande TERM servait à connecter ou à déconnecter de manière interne les bornes d'entrée du multimètre. Le 3458A accepte la commande TERM pour préserver la compatibilité du langage avec ces multimètres mais ne répond pas à cette commande dans la mesure où les bornes d'entrée du 3458A ne sont pas contrôlables à distance.

Syntaxe

TERM [source]

source Les choix de paramètres de source sont:

source paramètre	Équivalent numérique	Description
OPEN	0	Génère un message d'erreur
FRONT	1	Génère un message d'erreur (si le commutateur Terminals est sur Rear)
REAR	2	Génère un message d'erreur (si le commutateur Terminals est sur Front)

Source à la mise sous tension = aucune
Source par défaut = FRONT

Points importants

- **Commande d'interrogation:** La commande d'interrogation TERM? retourne une réponse indiquant les bornes d'entrée (FRONT ou REAR - Avant ou Arrière) sélectionnées par le commutateur **Terminals** du panneau avant

TEST

La commande TEST force le 3458A à effectuer une série d'auto-tests internes.

Syntaxe

TEST

Points importants

- Déconnectez toujours les signaux d'entrée éventuels avant d'effectuer les tests automatiques. Si un signal d'entrée reste connecté au multimètre, il risque de faire échouer le test.
- En cas d'erreur due au matériel, le multimètre positionne le bit 0 du registre d'erreur et un bit plus descriptif dans le registre d'erreur auxiliaire. Pour lire les registres d'erreur, utilisez ERRSTR? (les deux registres), ERR? (registre d'erreur uniquement) ou AUXERR? (registre d'erreur auxiliaire uniquement).
- **Commandes connexes:** AUXERR?, ERR?, ERRSTR?

Exemple

```
OUTPUT 722; . "TEST" !EFFECTUE LE TEST AUTOMATIQUE
```

TIMER

La commande TIMER définit l'intervalle de temps pour l'événement d'échantillonnage TIMER dans la commande NRDGS. Si vous utilisez l'événement TIMER, l'intervalle de temps spécifié est inséré entre les lectures.

Syntaxe

TIMER [*temps*]

temps Le paramètre temps doit être compris entre 1/vitesse d'échantillonnage maximale et 6000 secondes, par incréments de 100 ns.

Temps à la mise sous tension = 1 seconde

Temps par défaut = 1 seconde

Points importants

- Quand vous utilisez l'événement TIMER, la première lecture est effectuée sans tenir compte de l'intervalle de temps. Vous pouvez cependant insérer un retard avant la première lecture avec la commande DELAY.
- Quand vous utilisez l'événement TIMER, la fonction de changement de gamme automatique est suspendue (typiquement, vous sélectionneriez une gamme fixe avec l'événement TIMER). Si la gamme automatique était validée lorsque vous avez spécifié l'événement d'échantillonnage TIMER, elle sera reprise dès que vous spécifierez un événement d'échantillonnage autre que TIMER.
- La commande SWEEP peut être utilisée en remplacement des commandes NRDGS n , TIMER et TIMER n . Les commandes SWEEP et NRDGS sont interchangeables et le multimètre utilisera celle qui aura été exécutée en dernier. L'exécution de la commande SWEEP définit automatiquement l'événement d'échantillonnage à TIMER. Dans les états de mise sous tension, RESET ou PRESET, le multimètre utilise la commande NRDGS. Les valeurs de mise sous tension de SWEEP ne peuvent être spécifiées qu'en sous-échantillonnage (dans la mesure où ce mode de mesure n'accepte pas la commande NRDGS).
- Vous ne pouvez pas utiliser les événements TIMER (ou SWEEP) pour les mesures de tension alternative ou alternative + continue utilisant les méthodes synchrone ou aléatoire (SETACV SYNC ou RNDM) ni pour les mesures de fréquence ou de période.
- **Commande d'interrogation:** La commande d'interrogation TIMER? renvoie l'intervalle de temps courant, en secondes, de l'événement timer de NRDGS.
- **Commandes connexes:** DELAY, NRDGS, SWEEP

Exemple

```

10 OUTPUT 722;"TRIG HOLD"      !SUSPEND LES MESURES
20 OUTPUT 722;"INBUF ON"       !VALIDE LA MEMOIRE-TAMPON D'ENTREE
30 OUTPUT 722;"DCV 10"        !MESURES DE TENSION CONTINUE, GAMME 10V
40 OUTPUT 722;"NPLC .1"       !SELECTIONNE 0,1 PLC COMME TEMPS
45                             !D'INTEGRATION
50 OUTPUT 722;"AZERO OFF"     !INVALIDE LE ZERO ACTOMATIQUE
60 OUTPUT 722;"MEM FIFO"      !VALIDE LE MODE FIFO DE LA
65                             !MEMOIRE DE LECTURE

```

```
70 OUTPUT 722;"TIMER 2"      !INTERVALLE DE 2 SECONDES
80 OUTPUT 722;"NRDGS 10 TIMER" !10 LECTURES PAR EVENEMENT
85                          !D'ECHANTILLONNAGE (TIMER)
90 OUTPUT 722;"TRIG SGL"     !DECLENCHE UNE FOIS
100 END
```

TONE

La commande TONE force le multimètre à émettre une tonalité (unique), après quoi l'instrument revient au mode BEEP précédemment spécifié (OFF ou ON).

Syntaxe

TONE

Commandes connexes: BEEP

Exemple

```
OUTPUT 722; "TONE" !EMET UNE TONALITE
```

TRIG

La commande TRIG spécifie l'événement de déclenchement.

Syntaxe

TRIG [événement]

événement Les valeurs possibles du paramètre *événement* sont:

Paramètre événement	Équivalent numérique	Description
AUTO	1	Initialise une lecture à chaque fois que le multimètre est libre
EXT	2	Initialise une lecture sur la transition négative sur le connecteur Ext Trig du multimètre
SGL	3	Déclenche une fois (à réception d'un TRIG SGL) puis revient à TRIG HOLD

Paramètre événement	Équivalent numérique	Description
HOLD	4	Invalide les lectures
SYN	5	Initialise une lecture lorsque la mémoire-tampon de sortie du multimètre est vide, que la mémoire de lecture est invalidée ou vide et que le contrôleur demande des données
LEVEL ^[a]	7	Déclenche une lecture lorsque le signal d'entrée atteint la tension spécifiée par la commande LEVEL sur la pente spécifiée par la commande SLOPE
LINE ^[b]	8	Déclenche une lecture au passage de la tension secteur ca par zéro volt

[a] L'événement de déclenchement LEVEL ne peut être utilisé que pour les mesures de tension continue et en mode échantillonnage direct (numérisation).

[b] L'événement de déclenchement LINE ne peut pas être utilisé pour les mesures de tension alternative ou alternative + continue échantillonnées (SETACV RNDM ou SYNC) ni pour les périodes de fréquence ou de période.

Événement à la mise sous tension= AUTO

Événement par défaut= SGL

Points importants

- Pour toutes les mesures, exceptée le sous-échantillonnage (voir [chapitre 5](#)), l'événement de déclenchement opère avec les événements d'armement de déclenchement (commande TARM) et d'échantillonnage (commande NRDGS). (Les événements de déclenchement et d'échantillonnage sont ignorés en sous-échantillonnage). Pour effectuer une mesure, l'événement d'armement doit se produire, suivi de l'événement de déclenchement et finalement de l'événement d'échantillonnage. L'événement de déclenchement ne déclenche pas obligatoirement une mesure. Il ne fait que la permettre. La mesure est déclenchée lorsque l'événement d'échantillonnage (commande NRDGS ou SWEEP) se produit. Se référer à [Déclenchement des mesures](#) au [chapitre 4](#) pour une description approfondie de l'interaction des divers événements et au [chapitre 5](#) pour plus de détails sur le principe du sous-échantillonnage.
- **Commande d'interrogation:** La commande d'interrogation TRIG? renvoie l'événement de déclenchement spécifié. Pour plus de détails sur les [Commandes d'interrogation](#), se reporter au début du présent chapitre.

- **Commandes connexes:** LEVEL, LFILTER, NRDGS, SLOPE, SWEEP, T, TARM, TBUF

Exemples

```
OUTPUT 722; "TRIG AUTO" !SELECTIONNE LE DECLENCHEMENT
!AUTOMATIQUE
```

Le programme suivant illustre une méthode de suspension de mesures jusqu'à ce que le multimètre soit correctement configuré. La ligne 20 interrompt les mesures en définissant l'événement de déclenchement à HOLD. Les lignes 30 et 40 configurent le multimètre pour 30 mesures de tension continue par déclenchement. La ligne 50 génère un déclenchement unique qui force le multimètre à effectuer 30 lectures. Une fois les lectures terminées, l'événement de déclenchement repasse à HOLD.

```
10 OUTPUT 722;"RESET" !CONFIGURE LE MULTIMETRE A L'ETAT
20 OUTPUT 722;"TRIG HOLD" !SUSPEND LES LECTURES
30 OUTPUT 722;"DCV 10" !MESURES DE TENSION CONTINUE, GAMME 10 V
40 OUTPUT 722;"NRDGS 30,AUTO" !30 LECTURES PAR EVENEMENT
45 !D'ECHANTILLONNAGE (AUTO)
50 OUTPUT 722;"TRIG SGL" !GENERE UN DECLENCHEMENT UNIQUE
60 END
```

A Spécifications

Pour les caractéristiques et spécifications du 3458A multimètre, référez-vous à la fiche de données à l'adresse <http://literature.cdn.keysight.com/litweb/pdf/5965-4971E.pdf>.

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B Commandes GPIB

Introduction 414

Introduction

Les commandes GPIB figurant dans cette annexe sont spécifiques aux ordinateurs Keysight série 200/300. Tout contrôleur IEEE-488 peut envoyer ces messages; la Syntaxe peut toutefois différer de celle indiquée ici. La terminologie IEEE-488 apparaît entre parenthèses après chaque intitulé de commande. Tous les exemples et instructions supposent un code de sélection d'interface de 7 et une adresse d'instrument de 22. Le **tableau B-1** montre les fonctions GPIB du multimètre.

Tableau B-1 Fonctions GPIB

Fonctions IEEE 488.1	Code	Description
Protocole source	SH1	Permet au multimètre de transmettre correctement des messages multi-lignes.
Protocole accepteur	AH1	Permet au multimètre de garantir une réception correcte des messages multi-lignes.
Emetteur	T5	Configure le multimètre en «Emetteur», ce qui lui permet d'envoyer des données par le bus GPIB. Cette configuration lui permet également de répondre à une scrutation série.
Récepteur	L4	Configure le multimètre en «Récepteur», ce qui lui permet de recevoir des informations par le bus GPIB.
Demande de service	SR1	Permet au multimètre d'envoyer une demande de service au contrôleur, en mode asynchrone.
Distant/Local	RL1	Permet au multimètre d'être programmé par le bus GPIB (à distance) ou à partir de son panneau avant (localement).
Scrutation parallèle	PPO	Non applicable.
Libérer Appareil	DC1	Permet au multimètre d'être initialisé à un état prédéfini par une commande Device Clear générée par le contrôleur.
Déclenchement Appareil	DT1	Permet au multimètre d'être déclenché par le bus GPIB (à distance).
Fonction de contrôler	CO	Non applicable.
Circuit électroniques	E2	Décrit les circuit-pilote électroniques utilisés par le multimètre (E2 = trois-états, 1 Mo/seconde maximum.)

ABORT 7 (IFC)

La commande ABORT initialise les circuits d'interface du Keysight 3458A.

Syntaxe

ABORT 7

Exemple

```
ABORT 7      ! INITIALISE LES CIRCUITS D'INTERFACE DU
```

CLEAR (DCL or SDC)

La commande CLEAR initialise le Keysight 3458A et le prépare à recevoir une commande. La commande CLEAR:

- Efface la mémoire tampon de sortie.
- Efface la mémoire tampon d'entrée.
- Interrompt l'exécution de sous-programme.
- Efface le registre d'état (les bits 4, 5 et 6 ne sont pas remis à 0 si la condition qui les valide existe toujours).
- Efface l'affichage
- Invalide le déclenchement. Le précédent mode de déclenchement peut être validé en envoyant l'une des commandes du multimètre.

Syntaxe

CLEAR 7

CLEAR 722

Exemples

```
CLEAR 7      ! INITIALISE TOUS LES INSTRUMENTS (DCL)
              ! SUR LE BUS (CODE DE SELECTION 7)
```

```
CLEAR 722    ! INITIALISE L'INSTRUMENT (SDC) A
              ! L'ADRESSE 22 (CODE DE SELECTION 7)
```

LOCAL (GTL)

La commande LOCAL fait sortir le Keysight 3458A du mode de commande à distance et valide son clavier (si celui-ci n'a pas été invalidé avec la commande LOCK du jeu de commandes du Keysight 3458A).

Syntaxe

LOCAL 7

LOCAL 722

Points importants

- Si la touche LOCAL du Keysight 3458A a été invalidée par LOCAL LOCKOUT, la commande LOCAL 722 valide le clavier mais la prochaine commande à distance l'invalidé. La commande LOCAL 7 par contre, redonne le contrôle au panneau avant même après un autre message à distance.

Exemples

LOCAL 7 ! POSITIONNE LA LIGNE REN GPIB AU NIVEAU FAUX (TOUS LES INSTRUMENTS SE METTENT EN LOCAL) (VOUS DEVEZ EXECUTER REMOTE 7 POUR REVENIR AU MODE DE COMMANDE A DISTANCE)

LOCAL 722 ! ENVOIE UN GTL GPIB A L'INSTRUMENT A L'ADRESSE 22 (ENSUITE, L'EXECUTION D'UNE COMMANDE DU MULTIMETRE OU REMOTE 722 REPLACE L'INSTRUMENT EN MODE DE COMMANDE A DISTANCE).

LOCAL LOCKOUT (LLO)

La commande LOCAL LOCKOUT invalide la touche LOCAL du Keysight 3458A.

Syntaxe

LOCAL LOCKOUT 7

Points importants

- Si le Keysight 3458A est dans l'état local quand vous envoyez LOCAL LOCKOUT, il reste en LOCAL. S'il est en mode à distance, sa touche LOCAL et son clavier sont immédiatement invalidés.

- Après avoir invalidé la touche LOCAL avec LOCAL LOCKOUT, vous ne pouvez la re-valider qu'en envoyant la commande GPIB LOCAL 7 ou en arrêtant / redémarrant l'instrument. Si la touche LOCAL du Keysight 3458A est invalidée par LOCAL LOCKOUT, la commande LOCAL 722 valide le clavier mais une autre commande à distance l'invalidé. Cependant, la commande LOCAL 7 valide la touche LOCAL et la laisse validée même après un autre message à distance.
- Si le clavier du Keysight 3458A est invalidé à la fois par la commande LOCAL LOCKOUT et par la commande LOCK, vous devez annuler ces deux commandes pour reprendre le contrôle du clavier. LOCAL LOCKOUT est annulé par la commande LOCAL. LOCK est annulé en configurant LOCK sur OFF.

Exemples

```

10 REMOTE 722      ! CONFIGURE L'INSTRUMENT A L'ADRESSE 22
15                ! EN MODE A DISTANCE
20 LOCAL LOCKOUT 7 ! LOCAL LOCKOUT (LLO) A TOUS LES
25                ! INSTRUMENTS SUR LE BUS
30 END

```

REMOTE

La commande REMOTE met la ligne REN du GPIB au niveau vrai.

Syntaxe

REMOTE 7
REMOTE 722

Points importants

- La commande REMOTE 7'12 place le Keysight 3458A dans le mode à distance. La commande REMOTE 7 ne suffit pas en elle-même à placer le Keysight 3458A dans l'état de commande à distance. Une fois la commande REMOTE 7 reçue, le Keysight 3458A ne passera en mode de commande à distance qu'après avoir été adressé.
- Dans la plupart des cas, vous n'utiliserez la commande REMOTE qu'après une commande LOCAL. REMOTE est indépendante de toute autre activité GPIB et est envoyée sur une ligne de bus spéciale, la ligne REN. La plupart des

contrôleurs mettent la ligne REN au niveau vrai à la mise sous tension ou en cas de réinitialisation.

Exemples

```
REMOTE 7      ! CONFIGURE LA LIGNE REN GPIB AU NIVEAU
               ! VRAI
```

La ligne ci-dessus ne suffit pas, par elle-même, à placer le Keysight 3458A en mode de commande à distance. Le Keysight 3458A ne passera en mode de commande à distance qu'une fois adressé (par exemple en envoyant OUTPUT 722.;"BEEP").

```
REMOTE 722    ! CONFIGURE LA LIGNE REN AU NIVEAU VRAI
               ! ET ADRESSE L 'INSTRUMENT 22
```

La ligne ci-dessus place le Keysight 3458A en mode de commande à distance.

SPOLL (scrutation série)

La commande SPOLL, comme la commande STB? du jeu de commandes du Keysight 3458A, renvoie un nombre représentant les bits positionnés dans le registre d'état (octet d'état). Le nombre retourné est la somme pondérée de tous les bits positionnés.

Syntaxe

P=SPOLL (722)

Bits du registre d'état

Les bits du registre d'état et les valeurs correspondantes sont:

Numéro d u bit	Valeur numérique	Description
0	1	Exécution de la mémoire de programme terminée
1	2	Limite inférieure ou supérieure dépassée
2	4	Touche SRQ du panneau avant actionnée

Numéro du bit	Valeur numérique	Description
3	8	SRQ de mise sous tension
4	16	Prêt pour instructions
5	32	Erreur (consulter le registre d'erreur)
6	64	Service demandé
7	128	Données disponibles

Points importants

- Si la ligne de SRQ est mis au niveau vrai quand vous envoyez SPOLL, tous les bits du registre d'état sont mis à zéro si les conditions qui les avaient positionnés n'existent plus. Si la ligne de SRQ est au niveau faux quand vous envoyez SPOLL, le contenu du registre d'état n'est pas modifié.
- La commande SPOLL diffère de la commande STB? en ce que STB? interrompt le processeur du Keysight 3458A. Par conséquent, avec STB?, le Keysight 3458A apparaît toujours occupé (bit quatre à zéro). SPOLL extrait simplement l'octet d'état sans interrompre le microprocesseur. Vous pouvez donc utiliser SPOLL pour surveiller si le Keysight 3458A est prêt à recevoir d'autres instructions (ce que ne permet pas STB?).
- Si la mémoire tampon de sortie contient des données quand vous envoyez la commande SPOLL, ces données restent intactes. Par contre, si vous utilisez la commande STB?, elles sont remplacées par les données d'état.

Exemples

```

10 P=SPOLL (722) ! ENVOIE UNE SCRUTATION SERIE, RESPONSE
15              ! DANS LA VARIABLE P
20 DISP P       ! AFFICHE LA REPOSE
30 END

```

TRIGGER (GET)

Si le déclenchement est armé (voir commande TARM), la commande TRIGGER (Déclenchement d'exécution de groupe) déclenche une fois le Keysight 3458A, puis suspend le déclenchement.

Syntaxe

TRIGGER 7

TRIGGER 722

Points importants

- La commande TRIGGER génère un déclenchement simple quelle que soit la configuration de déclenchement en cours. Cependant, elle ne déclenche pas le Keysight 3458A si l'armement de déclenchement est configuré sur HOLD.
- Si l'exécution de la mémoire de sous-programme est interrompue par la commande PAUSE (du jeu de commandes du Keysight 3458A), la commande TRIGGER reprend l'exécution du sous-programme mais ne génère pas de déclenchement.

Exemples

```
TRIGGER 7      ! ENVOIE UN DECLenchement D'EXECUTION DE
                ! GROUPE (GET)
TRIGGER 722    ! ENVOIE UN DECLenchement D'EXECUTION DE
                ! GROUPE (GET) A L'INSTRUMENT A
                ! L'ADRESSE 22
```


C

Procédure de verrouillage des commutateurs des bornes avant/arrière et de la borne de protection

Introduction	422
Outils nécessaires	423
Procédure	424

Introduction

Les commutateurs des bornes avant/arrière et de la borne de Guard peuvent être verrouillés pour éviter que leurs configurations ne soient modifiées. Pour ce faire, enlevez d'abord tous les couvercles du Keysight 3458A. Enlevez ensuite les tiges-poussoirs des commutateurs Guard et Front/Rear. Placez ensuite les caches-commutateur sur les orifices dans lesquels passaient les tiges-poussoirs. Pour finir, réinstallez les couvercles de l'instrument.

AVERTISSEMENT

Les procédures figurant dans cette annexe doivent être effectuées par un technicien qualifié. Pour éviter tout risque de choc électrique, n'effectuez aucune de ces procédures, à moins que vous ne soyez expressément qualifié pour le faire.

Outils nécessaires

Il vous faudra:

- 1** Un tournevis cruciforme #1
- 2** Un tournevis Torx #TX 15
- 3** Un tournevis Torx #TX10

Procédure

La procédure d'installation du kit de verrouillage se décompose comme suit:

- Retrait des couvercles de l'instrument
- Retrait de la tige-poussoir de Guard
- Retrait de la tige-poussoir avant/arrière
- Installation du cache-commutateur
- Réinstallation des couvercles de l'instrument

Retrait des couvercles de l'instrument

Pour ce faire:

- 1** Enlevez toutes les connexions du 3458A.
- 2** Mettez l'instrument hors tension.
- 3** Référez-vous à la **figure C-1**. Tournez l'instrument de façon à ce que son côté droit (par rapport à la face avant) soit face à vous.

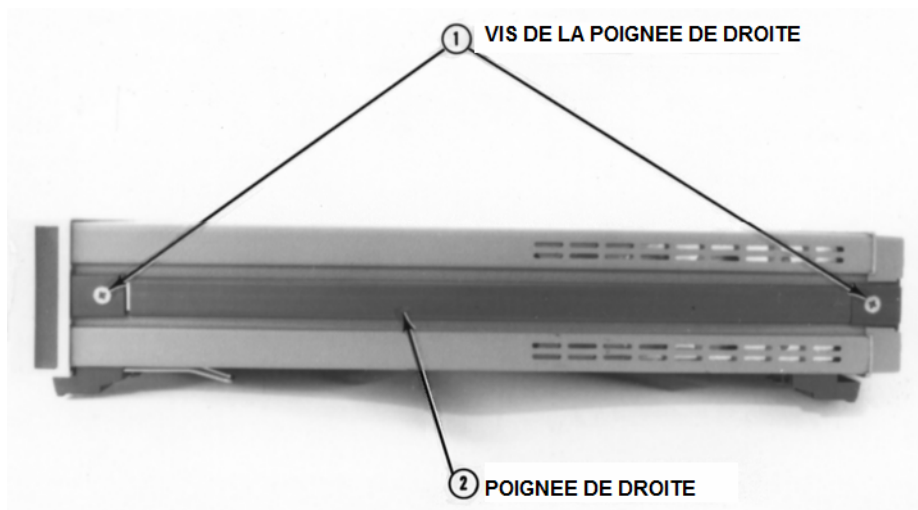


Figure C-1 Côté droit du 3458A

- 4 Enlevez les vis qui maintiennent la poignée de droite à l'aide du tournevis cruciforme #1 puis retirez la poignée.
- 5 Référez-vous à la **figure C-2**. Tournez l'instrument de façon à ce que son côté gauche soit face à vous.
- 6 Enlevez les vis qui maintiennent la poignée de gauche à l'aide du tournevis cruciforme #1 puis retirez la poignée.
- 7 A l'aide du tournevis Torx #TX10, retirez les vis de mise à la masse des couvercles supérieur et inférieur.
- 8 Référez-vous à la **figure C-4**. Tournez l'instrument de façon à ce que son côté arrière soit face à vous.
- 9 A l'aide du tournevis Torx #TX1S, enlevez les vis du support arrière puis retirez ce support.
- 10 Enlevez le couvercle supérieur en le tirant vers l'arrière.
- 11 Tournez le Keysight 3458A à l'envers de façon à ce que sa face supérieure repose sur votre établi. Enlevez le couvercle inférieur en le tirant vers l'arrière. Laissez l'instrument dans cette position.

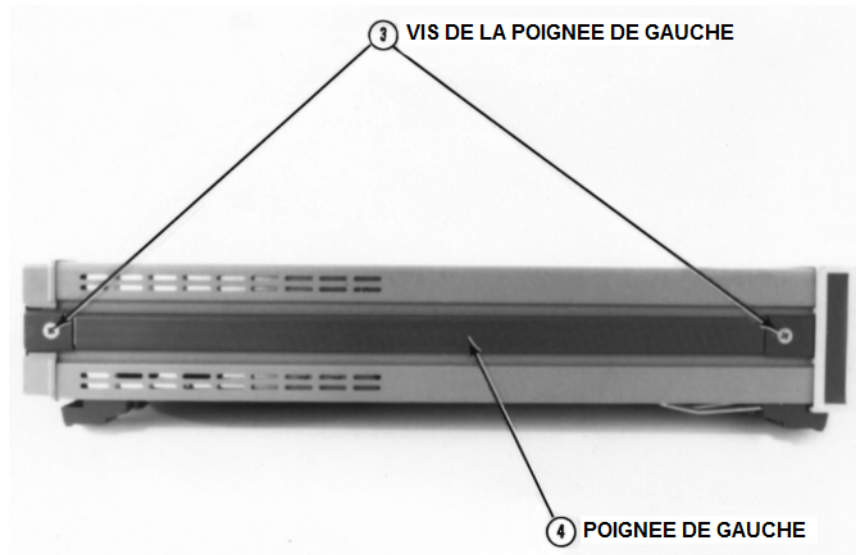


Figure C-2 Côté gauche du 3458A

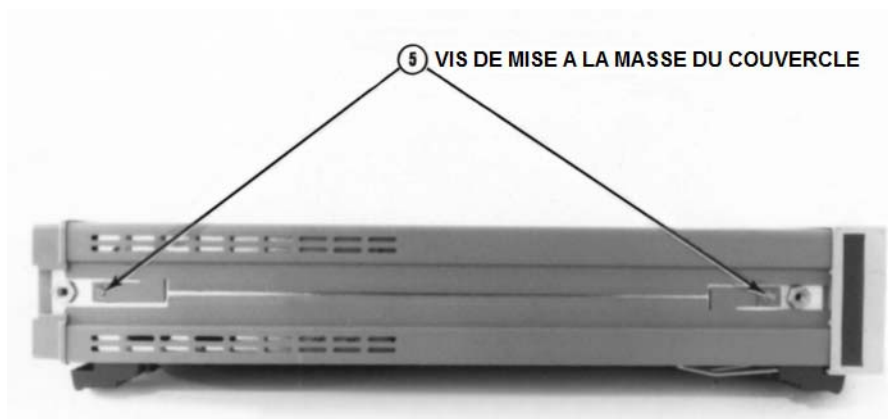


Figure C-3 Vis de mise à la masse du couvercle

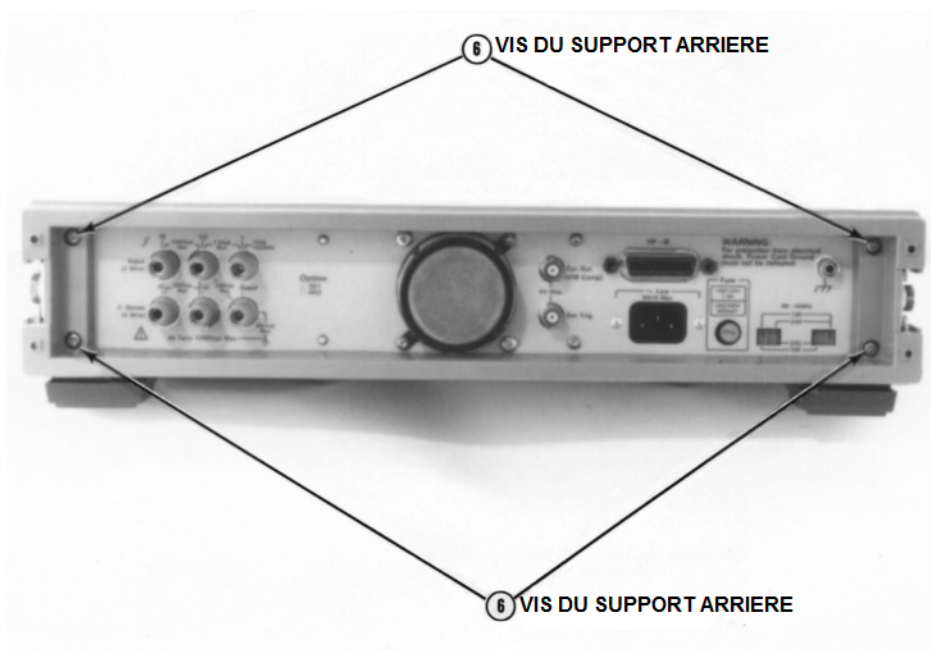


Figure C-4 Vue arrière du 3458A

Retrait de la tige-poussoir de Guard

Si vous ne désirez pas verrouiller le commutateur de GUARD, passez directement au paragraphe suivant.

- 1 Référez-vous à la **figure C-5**. A l'aide du tournevis Torx #TX10, enlevez la vis du blindage inférieur et retirez le blindage en le tirant vers l'arrière jusqu'à ce que les arrêts du blindage soient dans l'alignement des encoches du blindage. Retirez le blindage en le soulevant.
- 2 Référez-vous à la **figure C-6**, Localisez la tige-poussoir du commutateur Guard. Si besoin est, utilisez un tournevis à lame plate comme levier pour la retirer. Configurez le commutateur dans la position souhaitée.
- 3 Référez-vous à la **figure C-5**. Remplacez le blindage. Alignez les encoches du blindage sur les arrêts puis poussez le blindage vers l'avant de l'instrument jusqu'à ce que les trous des vis soient dans l'alignement de celui du châssis. Réinstallez le blindage à l'aide d'un tournevis Torx #TX10.

Retrait de la tige-poussoir avant/arrière

Si vous ne désirez pas verrouiller le commutateur des bornes avant/arrière, passez directement au paragraphe suivant.

- 1 Référez-vous à la **figure C-7**. Retournez l'instrument de façon à ce que sa face inférieure repose sur votre établi.
- 2 A l'aide du tournevis Torx #TX10, enlevez la vis du blindage supérieur et retirez le blindage en le tirant vers l'arrière de l'instrument jusqu'à ce que les arrêts du blindage soient dans l'alignement des encoches du blindage. Retirez le blindage en le soulevant.

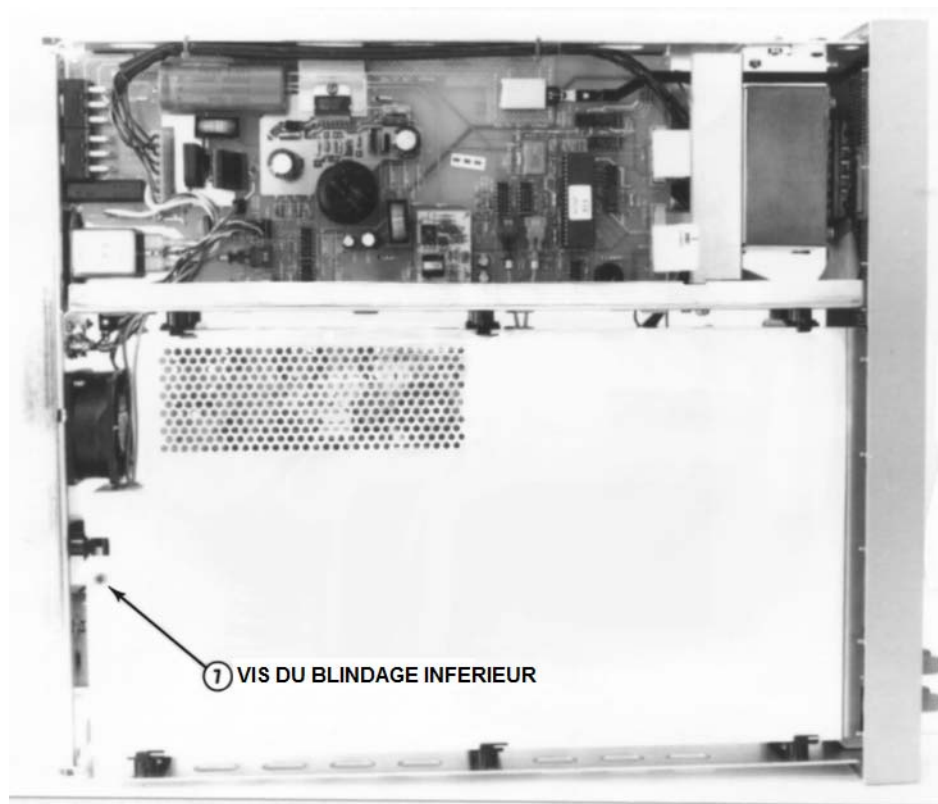


Figure C-5 Face inférieure du 3458A

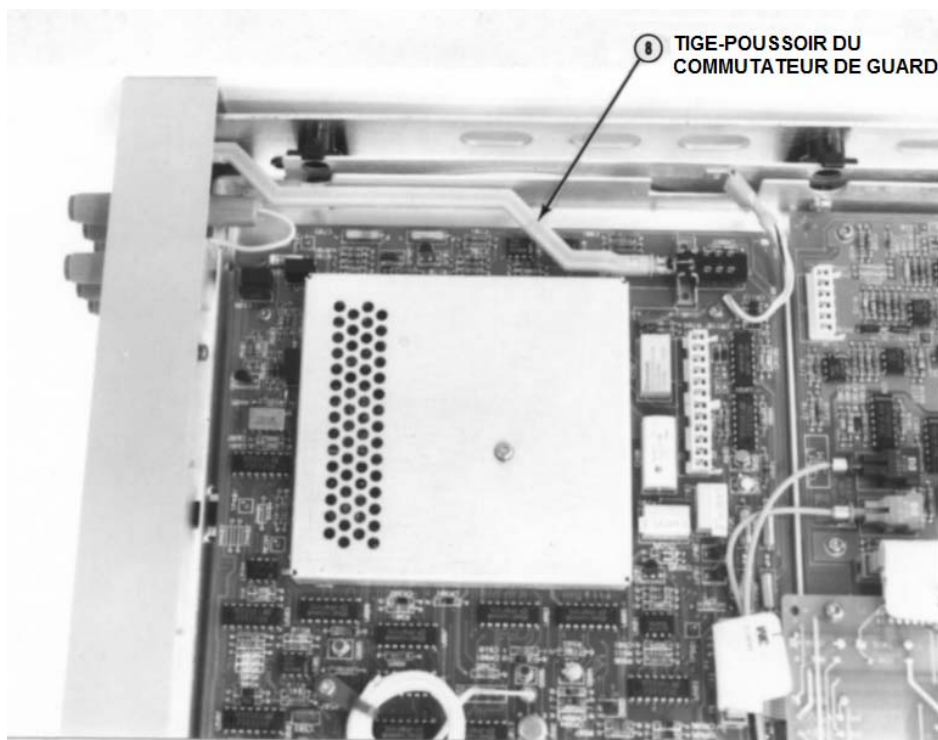


Figure C-6 Emplacement du commutateur GUARD et de sa tige-poussoir

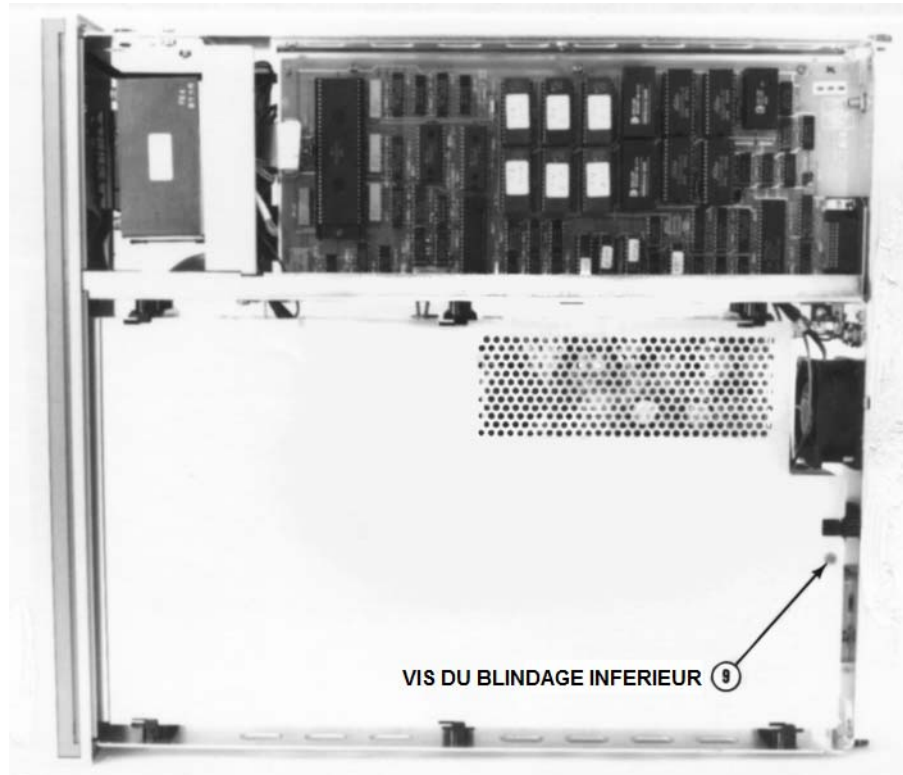


Figure C-7 Face supérieure du 3458A

- 3** Référez-vous à la [figure C-8](#). Localisez la tige-poussoir du commutateur Avant/arrière (Front/Rear). Si besoin est, utilisez un tournevis à lame plate comme levier pour la retirer. Configurez le commutateur dans la position souhaitée.
- 4** Référez-vous à la [figure C-7](#). Remplacez le blindage. Alignez les encoches du blindage sur les arrêts puis poussez le blindage vers l'avant de l'instrument jusqu'à ce que les trous des vis soient dans l'alignement de celui du châssis. Réinstallez le blindage à l'aide d'un tournevis Torx #TX10.

Installation des caches-commutateur

Pour ce faire:

- 1** Référez-vous à la **figure C-9**. Tournez l'instrument de façon à ce que sa face avant soit devant vous.
- 2** Localisez les orifices correspondant aux commutateurs des bornes Front/Rear et Guard.
- 3** Prenez les petits caches carrés fournis avec le kit de verrouillage (illustrés à la **figure C-9**).
- 4** Placez-les de façon à ce que leurs onglets soient face aux bords supérieur et inférieur de l'orifice correspondant à Front/rear ou à Guard.
- 5** Serrez les onglets entre vos doigts et poussez le cache en force dans l'orifice du commutateur jusqu'à ce qu'il soit complètement obturé.
- 6** Répétez, si nécessaire, les étapes 4 et 5, pour obturer l'autre orifice avec un second cache.

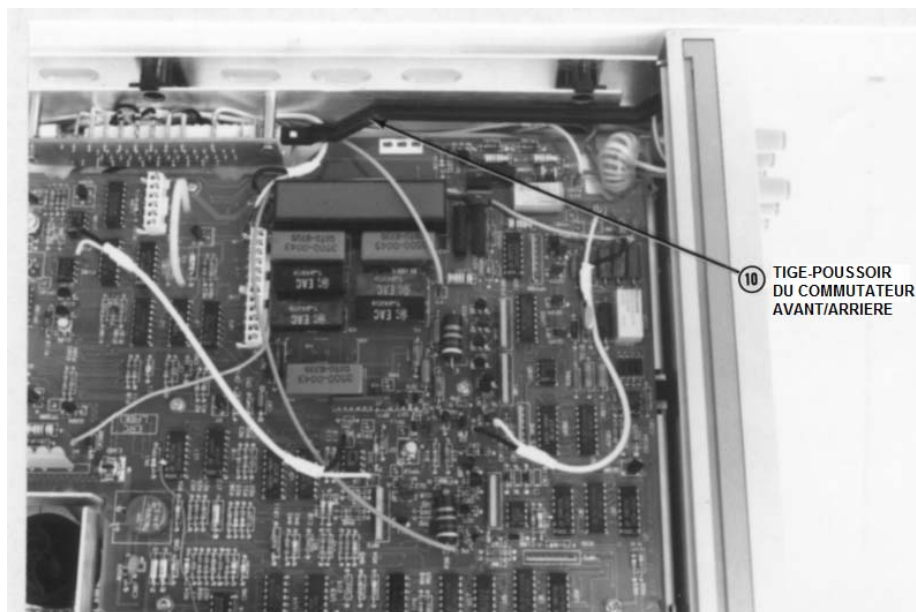


Figure C-8 Emplacement du commutateur des bornes avant/arrière et de sa tige-poussoir

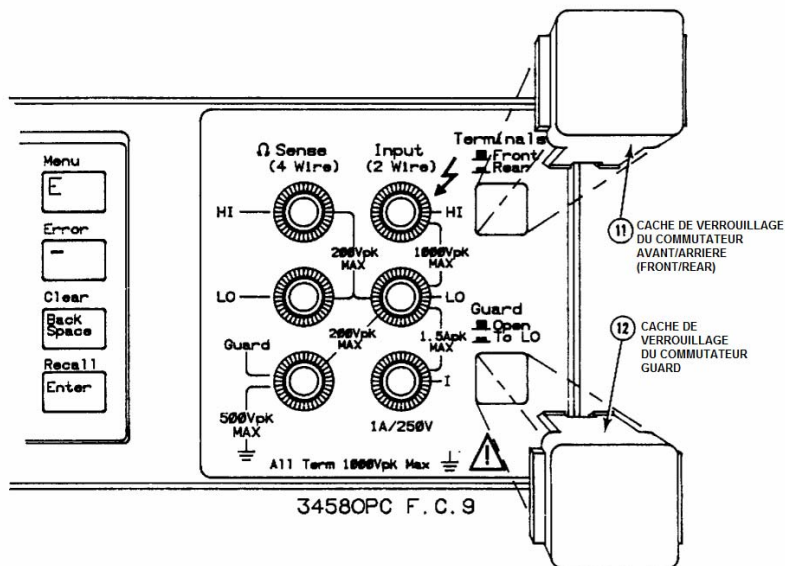


Figure C-9 Installation des caches sur les commutateurs

Installation des couvercles de l'instrument

Pour ce faire:

- 1 Tournez le Keysight 3458A de façon à ce que sa face supérieure repose sur votre établi.
- 2 Installez le couvercle inférieur en le plaçant dans les fentes prévues à cet effet dans les rainure latérales de l'instrument puis poussez le couvercle vers l'avant de l'instrument jusqu'à la plaquette du panneau avant.
- 3 Tournez le Keysight 3458A de façon à ce que sa face inférieure repose sur votre établi.
- 4 Installez le couvercle supérieur en le plaçant dans les fentes prévues à cet effet dans les rainures latérales de l'instrument puis poussez le couvercle vers l'avant de l'instrument jusqu'à la plaquette du panneau avant.

- 5 Référez-vous à la **figure C-4**. Tournez le Keysight 3458A de façon à ce que sa face arrière soit face à vous.
- 6 Réinstallez le support arrière et revissez-le à l'aide du tournevis Torx #TX15.
- 7 Référez-vous à la **figure C-3**. Tournez le Keysight 3458A de façon à ce que son côté gauche soit face à vous puis à l'aide du tournevis Torx. #TX10, replacez les vis de mise à la masse des couvercles supérieur et inférieur.

AVERTISSEMENT

Pour des raisons de sécurité et pour que le multimètre fonctionne correctement, il est impératif de remettre les couvercles de l'instrument à la masse (voir étape 7).

- 8 Référez-vous à la **figure C-2**. Réinstallez la poignée de gauche en la vissant avec le tournevis cruciforme #1.
- 9 Référez-vous à la **figure C-1**. Tournez le Keysight 3458A de façon à ce que son côté droit soit face à vous.
- 10 Réinstallez la poignée de droite en la vissant avec le tournevis cruciforme #1
- 11 Votre instrument est maintenant prêt à fonctionner. Nous vous recommandons cependant de procéder à un étalonnage automatique (commande ACAL) immédiatement après avoir mis l'instrument sous tension.

Ces informations peuvent faire l'objet
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