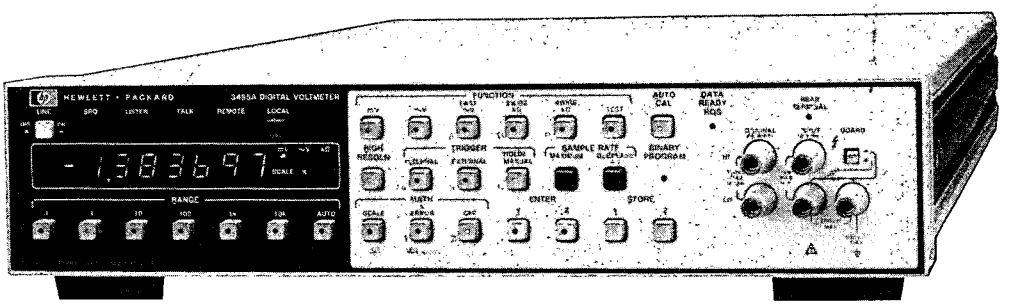
HEWLETT-PACKARD

HP 3455A Voltmeter

Operating Manual



MANUAL CHANGES

-hp- MODEL 3455A

DIGITAL VOLTMETER

Manual Part Number 03455-90013

CHANGE NO. 1. Applies to Serial Prefix 2519 and Above

Title Page. Add the following caution to the title page.

CAUTION

Your instrument may have either metric or English hardware. **DO NOT** *intermix the different hardware or damage to the instrument may result. Follow the cautions in the manual that pertain to the different hardware. Contact your local HP Office if more information is needed.*

Section I, Paragraph 1-14. Change the paragraph to the following:

1-14. The following options are available for the use of the Model 3455A.

Option 001: Average Responding AC Converter
Option 907: Front Handle Kit
(For Serial Prefix 1622 and below, use HP P/N 5061-0088
For Serial Prefix 2519 and above, use HP P/N 5061-9688)
Option 908: Rack Mounting Kit
(For Serial Prefix 1622 and below, use HP P/N 5061-0074
For Serial Prefix 2519 and above, use HP P/N 5061-9674)
Option 909: Front Handle Kit and Rack Mounting Kit
(For Serial Prefix 1622 and below, use HP P/N 5061-0075
For Serial Prefix 2519 and above, use HP P/N 5061-9675)
Option 910: Additional Set of Operating Information and Operating and Service Manuals

CAUTION

Your instrument may have either metric or English hardware. **DO NOT** *intermix the different hardware or damage to the instrument's frame and cabinet may result. For instruments with with serial prefix 2519 and above, use metric handle/rack mounting hardware, as listed above. For instruments with serial prefix 1622 and below, use English handle/rack mounting hardware also as listed above. Contact your local HP Office if more information is needed.*

CHANGE NO. 2. Applies to All Serial Numbers

Add the attached "DECLARATION" to the manual.

CHANGE NO. 3. Applies to All Serial Numbers

Section III, Paragraph 3-15. Add the following caution to the paragraph.

CAUTION

DO NOT *apply ac inputs greater than 500 V for more than two minutes, or damage to the ac circuitry can result.*

CHANGE NO. 4. Applies to Serial Number 2591A16021 and Above.

To increase turn-on reliability, a circuit modification has been made which will cause the 3455A to take 4-7 seconds to turn-on.

MANUAL CHANGES

-hp- MODEL 3455A

DIGITAL VOLTMETER

Manual Part Number 03455-90013

CHANGE NO. 1. Applies to Serial Prefix 2519 and Above

Title Page. Add the following caution to the title page.

CAUTION

Your instrument may have either metric or English hardware. **DO NOT** *intermix the different hardware or damage to the instrument may result. Follow the cautions in the manual that pertain to the different hardware. Contact your local HP Office if more information is needed.*

Section I, Paragraph 1-14. Change the paragraph to the following:

1-14. The following options are available for the use of the Model 3455A.

Option 001: Average Responding AC Converter
Option 907: Front Handle Kit
(For Serial Prefix 1622 and below, use HP P/N 5061-0088
For Serial Prefix 2519 and above, use HP P/N 5061-9688)
Option 908: Rack Mounting Kit
(For Serial Prefix 1622 and below, use HP P/N 5061-0074
For Serial Prefix 2519 and above, use HP P/N 5061-9674)
Option 909: Front Handle Kit and Rack Mounting Kit
(For Serial Prefix 1622 and below, use HP P/N 5061-0075
For Serial Prefix 2519 and above, use HP P/N 5061-9675)
Option 910: Additional Set of Operating Information and Operating and Service Manuals

CAUTION

Your instrument may have either metric or English hardware. **DO NOT** *intermix the different hardware or damage to the instrument's frame and cabinet may result. For instruments with with serial prefix 2519 and above, use metric handle/rack mounting hardware, as listed above. For instruments with serial prefix 1622 and below, use English handle/rack mounting hardware also as listed above. Contact your local HP Office if more information is needed.*

CHANGE NO. 2. Applies to All Serial Numbers

Add the attached "DECLARATION" to the manual.

CHANGE NO. 3. Applies to All Serial Numbers

Section III, Paragraph 3-15. Add the following caution to the paragraph.

CAUTION

DO NOT *apply ac inputs greater than 500 V for more than two minutes, or damage to the ac circuitry can result.*

CHANGE NO. 4. Applies to Serial Number 2591A16021 and Above.

To increase turn-on reliability, a circuit modification has been made which will cause the 3455A to take 4-7 seconds to turn-on.

5-24-79

HEWLETT PACKARD

OPERATING INFORMATION

MODEL 3455A

DIGITAL VOLTMETER

Serial Numbers 1622A00101 and Greater

NOTICE

This Manual is a duplication of sections I through III of your Operating and Service Manual.

Keep With Instrument

WARNING

To help minimize the possibility of electrical fire or shock hazards, do not expose this instrument to rain or excessive moisture.

Manual Part No. 03455-90013

Microfiche Part No. 03455-90063

RESTRICTED RIGHTS LEGEND

Use, duplication, or disclosure by the Government is subject to restrictions as set forth in subdivision (b)(3)(ii) of the Rights in Technical Data and Computer Software clause at 52.227-7013.

Hewlett-Packard Company
3000 Hanover Street, Palo Alto, California 94304

©Copyright Hewlett-Packard Company 1976
P.O. Box 301, Loveland, Colorado, 80537 U.S.A.

Printed: November 1979

TABLE OF CONTENTS

Section Page

I. GENERAL INFORMATION....1-1
1-1. Introduction....1-1
1-5. Specifications....1-1
1-7. Instrument and Manual Identification...1-1
1-11. Description....1-1
1-13. Options....1-1
1-15. Accessories Supplied....1-1
1-17. Accessories Available....1-1
1-19. Recommended Test Equipment....1-1

Section Page

II. INSTALLATION....2-1
2-1. Introduction....2-1
2-3. Initial Inspection....2-1
2-5. Preparation for Use....2-1
2-6. Power Requirements....2-1
2-8. Line Voltage Selection....2-1
2-10. Power Cable....2-1
2-12. Grounding Requirements....2-1
2-14. Bench Use....2-1
2-16. Rack Mounting....2-2
2-18. Interface Connections....2-2
2-22. Environmental Requirements....2-2
2-23. Operating and Storage Temperature...2-2
2-26. Humidity....2-3
2-28. Altitude....2-3
2-30. Repackaging for Shipment....2-3

Section Page

III OPERATING INSTRUCTIONS....3-1
3-1. Introduction....3-1
3-3. Operating Characteristics....3-1
3-4. Turn-On and Warm-Up....3-1
3-6. Self-Test Operation....3-1
3-10. DC Voltage Measurement....3-1
3-12. Resistance Measurement....3-2
3-14. AC Voltage Measurement....3-2
3-19. Math Feature....3-3
3-23. Enter and Store....3-4
3-27. High Resolution Mode....3-4
3-29. Auto-Cal....3-5
3-33. Trigger....3-5
3-36. Sample Rate....3-5
3-38. Auto Range....3-6
3-41. Guarding....3-6
3-42. Common-Mode Voltages....3-6
3-44. Guard Connection....3-6
3-46. Guarding Information....3-6
3-48. Remote Operation....3-7
3-49. General....3-7
3-53. Address Selection....3-7
3-56. Program Codes....3-8
3-61. Data Messages....3-9
3-69. Device Control Messages....3-12
3-78. Interrupt and Device Status Messages....3-12
3-82. Data Output Characteristic....3-13
3-84. Bail Out Message....3-13
3-86. Instrument Measurement Times (Remote Control)....3-13
3-88. Remote Programming Examples....3-14
3-90. Operators Checks....3-14
3-92. Bench Use....3-14
3-94. HP-IB Operation....3-14

APPENDIX

Page

A-1. Introduction....A-1
A-4. Program Example #1....A-1
A-5. Program Example #2....A-2

LIST OF TABLES

Table Page

1-1. Specifications....1-2
1-2. Typical Operating Characteristics....1-4
1-3. Recommended Test Equipment....1-6
3-1. Maximum Front Panel Reading Rates....3-6
3-2. HP-IB Interface Capability....3-7
3-3. Bus Messages....3-8
3-4. HP-IB Program Codes....3-9
3-5. Binary Program Codes....3-11
3-6. Typical HP-IB Controlled Measurement Times....3-14

LIST OF ILLUSTRATIONS

Figure Page

2-1. Line Voltage Selection....2-1
2-2. Power Cord Configuration....2-1
2-3. Typical HP-IB System Interconnections....2-2
3-1. Front and Rear Panel Features....3-0
3-2. Ohmmeter Measurement Connections....3-2
3-3. Connecting the Guard....3-7
3-4. Address Selection....3-8
3-5. Operational Verification Flowchart....3-15/3-16

HEWLETT PACKARD

Herstellerbescheinigung

Hiermit wird bescheinigt, daß das Gerät/System HP 3455A in Übereinstimmung mit den Bestimmungen von Postverfügung 1046/84 funkentstört ist.

Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerätes/Systems angezeigt und die Berechtigung zur Überprüfung der Serie auf Einhaltung der Bestimmungen eingeräumt.

Zusatzinformation fur Meß- und Testgeräte

Werden Meß- und Testgeräte mit ungeschirmten Kabeln und/oder in offenen Meßaufbauten verwendet, so ist vom Betreiber sicherzustellen, daß die Funk-Entstörbestimmungen unter Betriebsbedingungen an seiner Grundstücksgrenze eingehalten werden.

Manufacturer's declaration

This is to certify that the equipment HP 3455A is in accordance with the Radio Interference Requirements of Directive FTZ 1046/84. The German Bundespost was notified that this equipment was put into circulation, the right to check the series for compliance with the requirements was granted.

Additional Information for Test- and Measurement Equipment

If Test- and Measurement Equipment is operated with unscreened cables and/or used for measurements on open set-ups, the user has to assure that under operating conditions the Radio Interference Limits are still met at the border of his premises.

NOTICE

The information contained in this document is subject to change without notice.

HEWLETT-PACKARD MAKES NO WARRANTY OF ANY KIND WITH REGARD TO THIS MATERIAL, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Hewlett-Packard shall not be liable for errors contained herein of for incidental or consequential damages in connection with the furnishing, performance or use of this material.

Hewlett-Packard assumes no responsibility for the use or reliability of its software on equipment that is not furnished by Hewlett-Packard.

This document contains proprietary information which is protected by copyright. All rights are reserved. No part of this document may be photocopied, reproduced or translated to another program language without the prior written consent of Hewlett-Packard Company.

HEWLETT PACKARD

SAFETY SUMMARY

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 of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements. This is a Safety Class 1 instrument.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

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 INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DO NOT OPERATE A DAMAGED INSTRUMENT

Whenever it is possible that the safety protection features built into this instrument have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the instrument until safe operation can be verified by service-trained personnel. If necessary, return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DANGEROUS PROCEDURE WARNINGS

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

WARNING

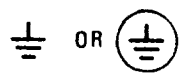
Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.

SAFETY SYMBOLS

General Definitions of Safety Symbols Used On Equipment or In Manuals.

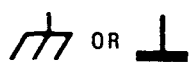
Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.

Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).



Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating equipment.

Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of a fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating the equipment.



Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.

Alternating current (power line).

Direct current (power line).

Alternating or direct current (power line).

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, condition or the like, which,if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

NOTE: The NOTE sign denotes important information. It calls attention to procedure, practice, condition or the like, which is essential to highlight.

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This Operating and Service Manual contains information necessary to install, operate, test, adjust, and service the Hewlett-Packard Model 3455A Digital Voltmeter.

1-3. Included with this manual is an Operating information supplement. The supplement is a duplication of the first three sections of this manual and should be kept with the instrument for use by the operator.

1-4. This section of the manual contains the performance specifications and general operating characteristics of the 3455A. Also listed are available options and accessories, and instrument and manual identification information.

1-5. SPECIFICATIONS.

1-6. Operating specifications for the 3455A are listed in Table 1-1. These specifications are the performance standards or limits against which the instrument is tested. Table 1-2 lists general operating characteristics of the instrument. These characteristics are not specifications but are typical operating characteristics included as additional information for the user.

1-7. INSTRUMENT AND MANUAL IDENTIFICATION.

1-8. Instrument identification by serial number is located on the rear panel. Hewlett-Packard uses a two-section serial number consisting of a four-digit prefix and a five-digit suffix separated by a letter designating the country in which the instrument was manufactured. (A = U.S.A.; G = West Germany; J = Japan; U = United Kingdom.) The prefix is the same for all identical instruments and changes only when a major instrument change is made. The suffix, however, is assigned sequentially and is unique to each instrument.

1-9. This manual applies to instruments with serial numbers indicated on the title page. If changes have been made in the instrument since this manual was printed, a yellow "Manual Changes" supplement supplied with the manual will define these changes and explain how to adapt the manual to the newer instruments. In addition, backdating information contained in Section VII adapts the manual to instruments with serial numbers lower than those listed on the title page.

1-10. Part numbers for the manual and the microfiche copy of the manual are also listed on the title page.

1-11. DESCRIPTION.

1-12. The Model 3455A Digital Voltmeter makes ac voltage measurements with five digit resolution and dc voltage and resistance measurements with 5 or 6 digit resolution as programmed by the user. The 3455A employs an automatic calibration (AUTO CAL) feature which automatically corrects for possible gain and offset errors in the analog circuitry to provide maximum accuracy. A removable reference module permits external calibration of the dc voltage and resistance functions. The reference module can be removed, calibrated and returned to the instrument, or the module can be replaced with another recently calibrated reference. A MATH feature permits voltage or resistance measurements to be scaled into convenient units or to be read directly in percent error from a selected reference. The 3455A is HP-IB programmable for system applications.

NOTE

HP-IB is Hewlett-Packard's implementation of IEEE std 488-1975, "standard digital interface for programmable instrumentation".

1-13. OPTIONS.

1-14. The following options are available for usé with the Model 3455A:

Option 001: Average Responding AC Converter
Option 907: Front Handle Kit
Option 908: Rack Mounting Kit
Option 909: Front Handle and Rack Mounting Kit
Option 910: Additional Set of Operating Information and Operating and Service Manuals

1-15. Accessories Supplied.

1-16. A service kit (-hp- Part No. 03455-84411) consisting of a PC extender board and a fuse is supplied with the Model 3455A.

1-17. ACCESSORIES AVAILABLE.

1-18. The following is a list of accessories available for use with the Model 3455A.

Accessory No.	Description
11177A	3455A Reference Module
34111A	High Voltage Probe (40 kV dc)
10631A	HP-IB Cable 1 meter (39.37 in.)
10631B	HP-IB Cable 2 meter (78.74 in.)
10631C	HP-IB Cable 4 meter (157.48 in.)

1-19. Recommended Test Equipment.

1-20. Equipment required to maintain the Model 3455A is listed in Table 1-3. Other equipment may be substituted if it meets the requirements listed in the table.

Table 1-1. Specifications.

DC Voltage

Specifications apply with Auto-Cal ON

Ranges: High Resolution Off	Ranges: High Resolution On	Maximum Display: High Resolution Off	Maximum Display: High Resolution On
.1V	—	±.149999V	———
1V	1V	±1.49999V	±1.499999V
10V	10V	±14.9999V	±14.99999V
100V	100V	±149.999V	±149.9999V
1000V	1000V	±1000.00V	±1000.000V

Range Selection: Manual, Automatic, or Remote

Performance (High Resolution Off)

Temperature Coefficient: (0°C to 50°C)

0.1V range: ±(0.0003% of reading + 0.15 digits)/°C
1V range: ±(0.0003% of reading + 0.015 digits)/°C
10V range: ±(0.00015% of reading + 0.01 digits)/°C
100 & 1000V range: ±(0.0003% of reading + .01 digits)/°C

Accuracy: (1 digit = .001% of range):

24 hours; 23°C ±1°C
10V range: ±(0.002% of reading + 1 digit)
1V range: ±(0.003% of reading + 1 digit)
0.1V range: ±(0.004% of reading + 4 digits)
100 & 1000V range: ±(0.004% of reading + 1 digit)

90 days; 23°C ±5°C
10V range: ±(0.005% of reading + 1 digit)
1V range: ±(0.006% of reading + 1 digit)
0.1V range: ±(0.007% of reading + 4 digits)
100 & 1000V range: ±(0.007% of reading + 1 digit)

6 months; 23°C ±5°C
10V range: ±(0.008% of reading + 1 digit)
1V range: ±(0.009% of reading + 1 digit)
0.1V range: ±(0.010% of reading + 5 digits)
100 & 1000V range: ±(0.010% of reading + 1 digit)

1 year; 23°C ±5°C
10V range: ±(0.013% of reading + 1 digit)
1V range: ±(0.014% of reading + 1 digit)
0.1V range: ±(0.015% of reading + 6 digits)
100 & 1000V range: ±(0.015% of reading + 1 digit)

Performance (High Resolution On)

Temperature Coefficient: (0°C to 50°C)

1V range: ±(0.0003% of reading + 0.15 digits)/°C
10V range: ±(0.00015% of reading + 0.1 digits)/°C
100 & 1000V range: ±(0.0003% of reading + 0.1 digits)/°C

Accuracy: (1 digit = .001% of range)

24 hours; 23°C ±1°C
10V range: ±(0.002% of reading + 3 digits)
100 & 1000V range: ±(0.004% of reading + 3 digits)
1V range: ±(0.003% of reading + 4 digits)

90 days; 23°C ±5°C
10V range: ±(0.005% of reading + 3 digits)
100 & 1000V range: ±(0.007% of reading + 3 digits)
1V range: ±(0.006% of reading + 4 digits)

6 months; 23°C ±5°C
10V range: ±(0.008% of reading + 3 digits)
100 & 1000V range: ±(0.010% of reading + 3 digits)
1V range: ±(0.009% of reading + 5 digits)

1 year; 23°C ±5°C
10V range: ±(0.013% of reading + 3 digits)
100 & 1000V range: ±(0.015% of reading + 3 digits)
1V range: ±(0.014% of reading + 6 digits)

Input Characteristics

Input Resistance:
0.1V through 10V range: $>10^{10}$ ohms
100V and 1000V range: 10 megohm ±0.1%
(with Auto-Cal OFF)

Maximum Input Voltage:
High to Low Input Terminals: ±1000V peak
Guard to Chassis: ±500V peak
Guard to Low Terminal: ±200V peak

Normal Mode Rejection (NMR): NMR is the ratio of the peak normal-mode voltage to the peak error voltage in the reading.
50 Hz operation: > 60 dB at 50 Hz ± 0.1%
60 Hz operation: > 60 dB at 60 Hz ± 0.1%

Effective Common Mode Rejection (ECMR): ECMR is the ratio of the peak common-mode voltage to the resultant peak error voltage in the reading with 1 kΩ unbalance in low lead.
AC Input:
50 Hz operation: > 160 dB at 50 Hz ± 0.1%
60 Hz operation: > 160 dB at 60 Hz ± 0.1%
DC Input:
> 140 dB

Maximum Reading Rate:

60Hz Gate Length

	High Resolution Off	High Resolution On
Local	5 readings/sec.	3 readings/sec.
Remote	24 readings/sec.	6 readings/sec.

50Hz Gate Length

	High Resolution Off	High Resolution On
Local	3.5 readings/sec.	2.5 readings/sec.
Remote	22 readings/sec.	5 readings/sec.

Table 1-1. Specifications (Cont'd).

Ohms

Ranges:		Maximum Display:	
High Resolution Off	High Resolution On	High Resolution Off	High Resolution On
.1kΩ	———	.149999kΩ	———
1kΩ	1kΩ	1.49999kΩ	1.499999kΩ
10kΩ	10kΩ	14.9999kΩ	14.99999kΩ
100kΩ	100kΩ	149.999kΩ	149.9999kΩ
1000kΩ	1000kΩ	1499.99kΩ	1499.999kΩ
10000kΩ	10000kΩ	14999.9kΩ	14999.99kΩ

Range Selection: Manual, Automatic, or Remote

Function Selection: 2 wire k ohms or 4 wire k ohms

Performance (High Resolution Off)

Temperature Coefficient: (0°C to 50°C)

0.1kΩ range: (0.0003% of reading + 0.2 digits)/°C
1, 10 and 100kΩ range: (0.0003% of reading + 0.02 digits)/°C
1000kΩ range: (0.0005% of reading + 0.02 digits)/°C
10,000kΩ range: (0.004% of reading + 0.02 digits)/°C

Accuracy: 4 wire k ohms* (1 digit = .001% of range)

24 hours; 23°C ±1°C

0.1kΩ range: ±(0.003% of reading + 4 digits)
1kΩ range: ±(0.003% of reading + 1 digit)
10kΩ range: ±(0.005% of reading + 2 digits)
100kΩ range: ±(0.002% of reading + 2 digits)
1000kΩ range: ±(0.012% of reading + 5 digits)
10,000kΩ range: ±(0.1% of reading + 5 digits)

90 days; 23°C ±5°C

0.1kΩ range: ±(0.005% of reading + 5 digits)
1kΩ range: ±(0.005% of reading + 1 digit)
10kΩ range: ±(0.007% of reading + 2 digits)
100kΩ range: ±(0.004% of reading + 2 digits)
1000kΩ range: ±(0.014% of reading + 5 digits)
10,000kΩ range: ±(0.100% of reading + 5 digits)

6 months; 23°C ±5°C

0.1kΩ range: ±(0.005% of reading + 6 digits)
1kΩ range: ±(0.005% of reading + 1 digit)
10kΩ range: ±(0.007% of reading + 2 digits)
100kΩ range: ±(0.004% of reading + 3 digits)
1000kΩ range: ±(0.014% of reading + 5 digits)
10,000kΩ range: ±(0.100% of reading + 5 digits)

1 year; 23°C ±5°C

0.1kΩ range: ±(0.006% of reading + 7 digits)
1kΩ range: ±(0.006% of reading + 2 digits)
10kΩ range: ±(0.008% of reading + 3 digits)
100kΩ range: ±(0.005% of reading + 4 digits)
1000kΩ range: ±(0.015% of reading + 6 digits)
10,000kΩ range: ±(0.100% of reading + 6 digits)

Performance (High Resolution On)

Temperature Coefficient: (0°C to 50°C)

1, 10 and 100kΩ range: ±(0.0003% of reading + 0.2 digits)/°C
1000kΩ range: ±(0.0005% of reading + 0.2 digits)/°C
10,000kΩ range: ±(0.004% of reading + 0.2 digits)/°C

Accuracy: 4 wire k ohms*

24 hours; 23°C ±1°C

1kΩ range: ±(0.0025% of reading + 4 digits)
10kΩ range: ±(0.0045% of reading + 4 digits)
100kΩ range: ±(0.0020% of reading + 5 digits)
1000kΩ range: ±(0.0120% of reading + 4 digits)
10,000kΩ range: ±(0.1000% of reading + 4 digits)

90 days; 23°C ±5°C

1kΩ range: ±(0.0035% of reading + 5 digits)
10kΩ range: ±(0.0060% of reading + 5 digits)
100kΩ range: ±(0.0035% of reading + 6 digits)
1000kΩ range: ±(0.0135% of reading + 5 digits)
10,000kΩ range: ±(0.1000% of reading + 5 digits)

6 months; 23°C ±5°C

1kΩ range: ±(0.0040% of reading + 6 digits)
10kΩ range: ±(0.0065% of reading + 6 digits)
100kΩ range: ±(0.0040% of reading + 7 digits)
1000kΩ range: ±(0.0140% of reading + 6 digits)
10,000kΩ range: ±(0.1000% of reading + 6 digits)

1 year; 23°C ±5°C

1kΩ range: ±(0.0045% of reading + 7 digits)
10kΩ range: ±(0.0070% of reading + 7 digits)
100kΩ range: ±(0.0045% of reading + 8 digits)
1000kΩ range: ±(0.0145% of reading + 7 digits)
10,000kΩ range: ±(0.1000% of reading + 7 digits)

***Accuracy:** 2 wire k ohms

All accuracy specifications are the same as 4 wire k ohms except add 0.0004kΩ to all readings.

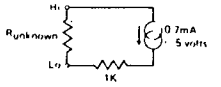
Input Characteristics

Maximum voltage generated across unknown:

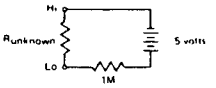
<5 volts for open circuit
<4.7 volts for valid reading

Signal Source Driving Unknown (Nominal):

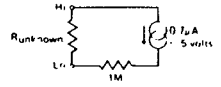
0.1kΩ, 1kΩ & 10kΩ ranges



100kΩ



1000kΩ & 10,000kΩ ranges



Overload Protection:

Non-Destructive — ±350V peak

Maximum Reading Rate:

60Hz Gate Length

	High Resolution Off	High Resolution On
Local	4.5 readings/sec.	2 readings/sec.
Remote	12 readings/sec.	3 readings/sec.

50Hz Gate Length

	High Resolution Off	High Resolution On
Local	4 readings//sec.	1.8 readings/sec.
Remote	11 readings/sec.	2.5 readings/sec.

Table 1-1. Specifications (Cont'd).

AC Voltage (RMS converter)

Ranges:	Maximum Display:
High Resolution On or Off	High Resolution On or Off
1V	1.49999V
10V	14.9999V
100V	149.999V
1000V	1000.00V

Range Selection: Manual, Automatic, or Remote

Function Selection: ACV or Fast ACV

Performance

Temperature Coefficient: (0°C to 50°C) for inputs <50kHz
AC coupled, input >1% of full scale: ±(0.002% of reading + 2 digits)/°C
AC coupled, input < 1% of full scale: ±(0.002% of reading + 6 digits)/°C
AC/DC coupled: ±(0.002% of reading + 6 digits)/°C

Accuracy: ±[% of reading + digits or (% of range)]¹ (AC Coupling)²

FAST ACV⁴ / ACV⁴	300Hz-20kHz / 30Hz-20kHz	20kHz-100kHz / 20kHz-100kHz	100kHz-250kHz³ / 100kHz-250kHz³	250kHz-500kHz³ / 250kHz-500kHz³	500kHz-1MHz³ / 500kHz-1MHz³
24 hrs; 23°C ±1°C	.04% + 40 dig. (.04%)	0.4% + 80 dig. (.08%)	1.8% + 200 dig. (.20%)	4% + 400 dig. (.40%)	5% + 2600 dig. (2.6%)
90 days; 23°C ±5°C	.05% + 50 dig. (.05%)	0.5% + 100 dig. (.10%)	2.0% + 250 dig. (.25%)	5% + 500 dig. (.50%)	6% + 3100 dig. (3.1%)
6 mos; 23°C ±5°C	.06% + 60 dig. (.06%)	0.6% + 130 dig. (.13%)	2.1% + 300 dig. (.30%)	5.1% + 600 dig. (.60%)	6.3% + 3500 dig. (3.5%)
1 year; 23°C ±5°C	.07% + 70 dig. (.07%)	0.7% + 160 dig. (.16%)	2.2% + 350 dig. (.35%)	5.3% + 700 dig. (.70%)	6.6% + 3900 dig. (3.9%)

¹Guard must be connected to low
Specifications are only for input levels above 1% of range
For AC coupled inputs · 1% of full scale add 20 digits to above accuracy table, except
For AC coupled inputs above 50kHz and · 5% of full scale add 170 digits to above accuracy table See footnote 2 for AC/DC coupled inputs

³For any AC/DC coupled input add (0.05% of reading + 20 digits) to above accuracy table, except
For an AC/DC coupled input above 50kHz and · 5% of full scale add 170 digits to above accuracy table
⁴Frequencies of greater than 100kHz are specified for the 1V and 10V ranges only
⁵Accuracy is not specified if the volt-hz product exceeds 10^7
For inputs >500V, multiply the above tabled accuracy by $\frac{1500 + |Vin|}{1000}$

Crest Factor: 7 : 1 at full scale

Input Characteristics

Input Impedance:
Front Terminals—2MΩ±1% shunted by less than 105pF
Rear Terminals—2MΩ±1% shunted by less than 90pF

Maximum Input Voltage:
High to Low Terminals: ± 1414 volts peak (Subject to a 10^7 volt - Hz limitation)
Guard to Chassis: ±500V peak
Guard to Low Terminal: ±200V peak

Maximum Reading Rate:

	60Hz Gate Length		50Hz Gate Length	
	ACV	FAST ACV	ACV	FAST ACV
Local	1.3 readings/sec.	4.5 readings/sec.	1.1 readings/sec.	3.5 readings/sec.
Remote	1.3 readings/sec.	13 readings/sec.	1.1 readings/sec.	12 readings/sec.

Response Time:
ACV and FAST ACV
First reading to <0.1% of step size when triggered coincident with step change when on correct range.
(for AC signals with no DC component)

Table 1-1. Specifications (Cont'd).

AC Voltage (Average Converter Opt. 001)

Ranges: High Resolution On or Off	**Maximum Display:** High Resolution On or Off
1V	1.49999V
10V	14.9999V
100V	149.999V
1000V	1000.00V

Range Selection: Manual, Automatic, or Remote

Function Selection: ACV or Fast ACV

Performance

Temperature Coefficient: (0°C to 50°C)
±(0.002% of reading + 2 digits)/°C

Accuracy: ±[% of reading + digits or (% of range)][1]

	FAST ACV[2] / ACV[3] **300Hz-500Hz** / **30Hz-50Hz**	**500Hz-1kHz** / **50Hz-100Hz**	**1kHz-100kHz** / **100Hz-100kHz**	**100kHz-250kHz[2]** / **100kHz-250kHz[2]**
24 hrs; 23°C ±1°C	0.47% + 70 dig. (.07%)	0.32% + 50 dig. (.05%)	0.09% + 25 dig. (.025%)	0.70% + 60 dig. (.06%)
90 days; 23°C ±5°C	0.50% + 70 dig. (.07%)	0.35% + 50 dig. (.05%)	0.1% + 25 dig. (.025%)	0.75% + 60 dig. (.06%)
6 mos; 23°C ±5°C	0.50% + 70 dig. (.07%)	0.40% + 60 dig. (.06%)	0.1% + 30 dig. (.03%)	0.75% + 70 dig. (.07%)
1 yr.; 23°C ±5°C	0.50% + 70 dig. (.07%)	0.40% + 70 dig. (.07%)	0.12% + 35 dig. (.035%)	0.75% + 80 dig. (.08%)

[1]Guard must be connected to Low
On the 1000V range, add 0.01 ppm/volt - kHz
Specifications are for input levels above 1/100th of range
[2]Frequencies greater than 100kHz specified on 1 and 10V ranges only
[3]Accuracy is not specified if the volt-hertz product exceeds 10^7

Input Characteristics

Input Impedance:
Front Terminals—2MΩ±1% shunted by less than 105pF
Rear Terminals—2MΩ±1% shunted by less than 90pF

Maximum Input Voltage:
High to Low Terminals: ± 1414 volts peak (Subject to a 10^7 volt - Hz limitation)
Guard to Chassis: ±500V peak
Guard to Low Terminal: ±200V peak

Maximum Reading Rate:

	60Hz Gate Length		**50Hz Gate Length**	
	ACV	**FAST ACV**	**ACV**	**FAST ACV**
Local	1.3 readings/sec.	4.5 readings/sec.	1.1 readings/sec.	3.5 readings/sec.
Remote	1.3 readings/sec.	13 readings/sec.	1.1 readings/sec.	12 readings/sec.

Response Time:
ACV and FAST ACV
First reading to <0.1% of step size when triggered coincident with step change when on correct range.
(for AC signals with no DC component)

Table 1-1. Specifications (Cont'd).

Math

Scale: $\left(\frac{X - Z}{Y}\right)$

X is present reading. Y and Z are previously entered readings, numbers entered from the front panel or values entered by external program.

Maximum Number: (Entered or Displayed)
±199,999.9

Accuracy:
±(ACCURACY OF X READING ±1 DIGIT OF DISPLAYED ANSWER)[1]

[1]This assumes no "Y" or "Z" error.

% Error: $\left(\frac{X - Y}{Y}\right)$ x 100%

X is present reading. Y is a previously entered reading, or number entered from the front panel or by external program.

Maximum Number: (Entered or Displayed)
±199,999.9

Accuracy:
±(ACCURACY OF X READING ± 1 DIGIT OF DISPLAYED ANSWER)[1]

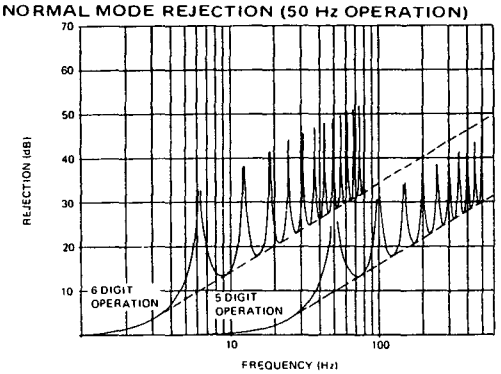
[1]This assumes no "Y" error.

Table 1-2. Typical Operating Characteristics.

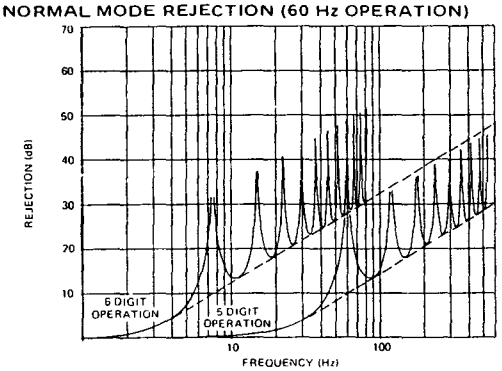
Range Selection: Manual, Automatic, or Remote

Function Selection:
DC Volts
AC Volts (ACV or FAST ACV)
OHMS (2 wire kilohm or 4 wire kilohm)
TEST

NORMAL MODE REJECTION (50 Hz OPERATION)



NORMAL MODE REJECTION (60 Hz OPERATION)

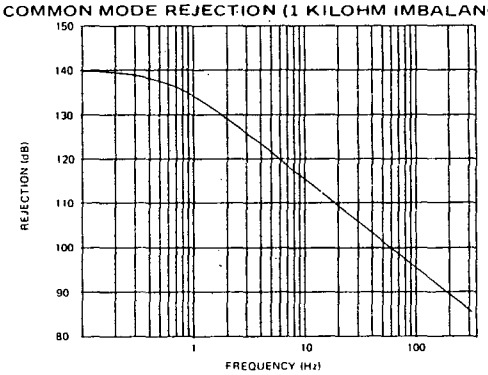


$$\text{Normal Mode Rejection} = 20 \log \left| \frac{\pi f T}{\sin \pi f T} \right|$$

Effective Noise Bandwidth = $\frac{1}{2T}$

T = 1/60 sec for 5 digit 60 Hz Operation
T = 2/15 sec for 6 digit 60 Hz Operation
T = 1/50 sec for 5 digit 50 Hz Operation
T = 4/25 sec for 6 digit 50 Hz Operation

COMMON MODE REJECTION (1 KILOHM IMBALANCE)



EFFECTIVE COMMON MODE REJECTION (50 Hz OPERATION)

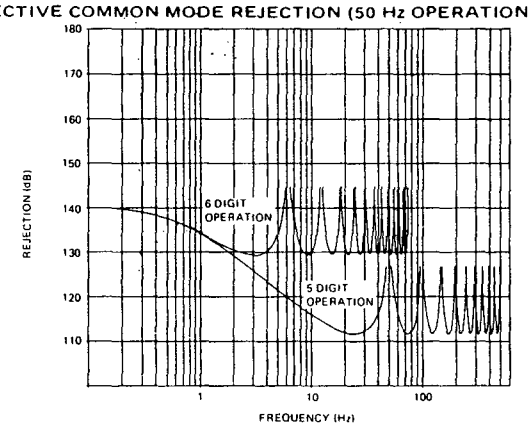
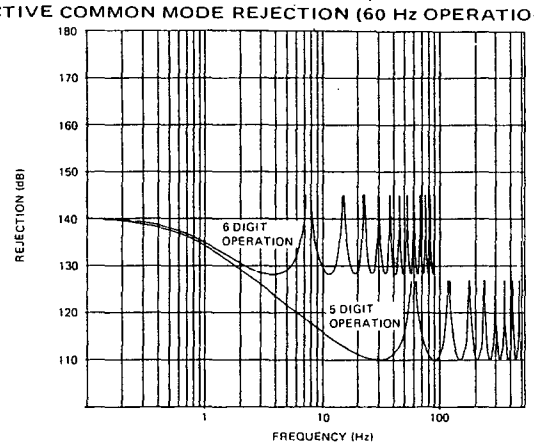


Table 1-2. Typical Operating Characteristics (Cont'd).

EFFECTIVE COMMON MODE REJECTION (60 Hz OPERATION)



Typical HP-IB Handshake Times:

Accept Data – (3455A addressed to listen or ATN true)
500 μsec per character typical (Ø delay source)

Output Data – (3455A addressed to talk)
250 μsec per character typical (Ø delay acceptor)

General (Auto Cal must be on for 75 seconds to meet all specifications)

Overload Indication: OL
Operating Temperature: 0°C to 50°C
Warmup Time: One hour to meet all specifications
Humidity Range: < 95% R.H., 0°C to 40°C
Storage Temperature: −40°C to +75°C
Power: 100/120/240 V +5%, −10% 48 Hz to 400 Hz line operation < 60 VA
220 V ± 10% 48 Hz to 400 Hz line operation < 60 VA
Dimensions: 88.9 mm high x 425.5 mm wide x 527.1 mm deep (3½" high x 16¾" wide x 20¾" deep)
Weights: Net – 9 kg (21 lbs.)
Shipping – 12 kg (26 lbs.)

1-21. SAFETY CONSIDERATIONS.

1-22. The 3455A is a safety class 1 instrument (provided with a protective earth terminal). The instrument and manual should be reviewed for safety symbols and instructions before operation.

Table 1-3. Recommended Test Equipment.

Instrument	Critical Specification	Recommended Model	Use
DC Voltage Standard	Voltage: 10 mV to 1000 V Accuracy: ± .005%	Systron Donner Model M107	PAT
AC Calibrator	Frequency: 20 Hz to 100 kHz Output Level: 100 mV to 1000 V Accuracy: ± .1% Voltage Stability (6 mos.) ± .02%	-hp- Model 745A AC Calibrator -hp- Model 746A High Voltage Amplifier	PAT
Test Oscillator	Frequency: to 250 kHz Output: 3 V rms into 50 Ω Frequency Response ± .25%	-hp- Model 652A Test Oscillator	P
Resistance Decade	Resistance: 100 Ω to 10 MΩ Accuracy: ± .004%	Gen Rad Model GR 1433-Z Decade Resistor	PAT
DC Null Voltmeter	Voltage Range: 1 μV to 10 V	-hp- Model 419A	PAT
Reference Divider	Division Ratio Accuracy ± .001% Output Voltage Range - 1 V to 1 kV	Fluke Model 750A Reference Divider	PA
DC Transfer Standard	Output Voltages: 1 V, 1.018 V, 1.019V, 10 V Accuracy: ± 5 ppm Stability: ± .001% (30 days)	Fluke Model 731A DC Transfer Standard	PA
Electronic Counter	50 Hz to 60 Hz	-hp- Model 5300A/5302A Measuring System	P
Resistance Standard	Resistance: 1 kΩ Accuracy: ± .0005% Resistance: 100 K Accuracy: ± .002%	Guildine Model 9330/1 K or 9330A/1 K Guildline Model 9330/100 K	A
Bus System Analyzer	HP-IB Control Capability	-hp- Model 59401A Bus System Analyzer	T
Calculator	HP-IB Control Capability must serve as printer for 3455A Output data.	-hp- Model 9825A	OT
Oscilloscope	Bandwidth: DC to 10 MHz Sweep Time: 0.1 μs to 1 sec/div Sensitivity: 1 V/div	-hp- Model 180C/D Oscilloscope with 1801A and 1821A plug-in units	T
Digital Voltmeter	Voltage Range: 10 mV to 1000 V Resolution: 10 μV	-hp- Model 3490A	PAT
Resistors	Resistances: 1 kΩ ± 10% 10 kΩ ± 0.1% 1 MΩ ± 0.1%	-hp- Part No. 0684-1021 0698-4157 0698-6369	P
Signature Analyzer		-hp- Model 5004A	T

P = Performance Checks
A = Adjustments
T = Troubleshooting
O = Operators Check

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary to install and interface the Model 3455A Digital Voltmeter. Also included are initial inspection procedures, power and grounding requirements, environmental information, and repackaging instructions.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be free of mars and scratches and in perfect electrical order. The instrument should be inspected upon receipt for damage that might have occurred in transit. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been mechanically and electrically checked. Procedures for testing electrical performance of the 3455A are given in Section IV. If the contents are incomplete, if there is mechanical damage or defect, or if the multimeter does not pass the Performance Tests, notify the nearest Hewlett-Packard Office. (A list of the -hp- Sales and Service Offices is presented at the back of the manual.) If the shipping container is damaged, or the cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard Office. Save the shipping materials for the carrier's inspection.

2-5. PREPARATION FOR USE.

2-6. Power Requirements.

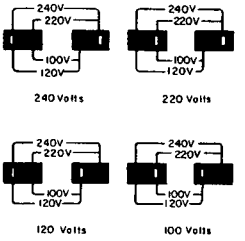
2-7. The Model 3455A requires a power source of 100, 120, 220, or 240 V ac (+5% - 10%), 48 Hz to 400 Hz single phase. Maximum power consumption is 60 VA.

2-8. Line Voltage Selection.

2-9. Before connecting ac power to the 3455A, make sure the rear panel line selector switches are set to correspond to the voltage of the available power line as shown in Figure 2-1. Also, be sure the proper fuse is installed. The multimeter is shipped with the line voltage and fuse selected for 120 V ac operation.

CAUTION

Be sure the 50 — 60 Hz rear panel switch is set for the proper line frequency for your location.



NOMINAL VOLTAGE	OPERATING RANGE −10%, +5% of nominal	FUSE
100 volts	90 to 105 volts	0.5 A
120 volts	108 to 126 volts	0.5 A
220 volts	198 to 231 volts	0.25 A
240 volts	216 to 252 volts	0.25 A

Figure 2-1. Line Voltage Selection.

2-10. Power Cable.

2-11. Figure 2-2 illustrates the standard configurations used for -hp- power cables. The -hp- part number directly below each drawing is the part number for a power cable equipped with a connector of that configuration. If the appropriate power cable is not included with the instrument, notify the nearest -hp- Sales and Service Office and the proper cable will be provided.

2-12. Grounding Requirements.

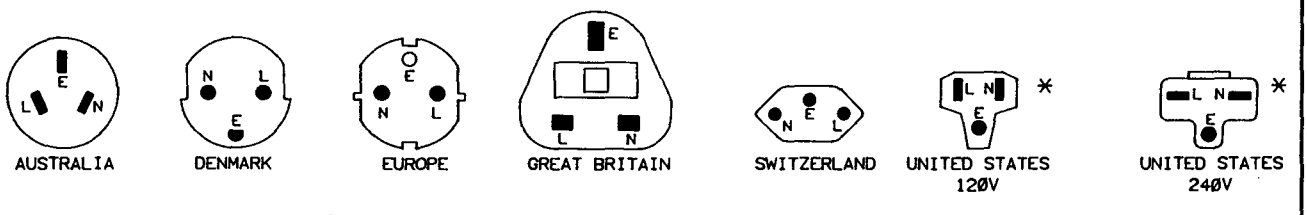
2-13. To protect operating personnel, the National Electrical Manufacturer's Association (NEMA) recommends that the instrument panel and cabinet be grounded. The Model 3455A is equipped with a three conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument.

2-14. Bench Use.

2-15. The Model 3455A is shipped with plastic feet and tilt stands installed and is ready for use as a bench instrument. The plastic feet are shaped to permit "stacking" with other full-module Hewlett-Packard instruments. The tilt stands permit the operator to elevate the front panel for operating and viewing convenience.

2-16. Rack Mounting.

2-17. The Model 3455A may be rack mounted by adding rack mounting kit Option 908 or Option 909. Option 908 contains the basic hardware and instructions for



Country	Part Number	Opt.	Voltage
Australia	8120-1369	901	250V 6A
Denmark	8120-2956	912	250V 6A
Europe	8120-1689	902	250V 6A
Great Britain	8120-1351	900	250V 6A
Switzerland	8120-2104	906	250V 6A
*United States	8120-1378	903	120V 10A
*United States	8120-0698	904	240V 10A

Power cords supplied by HP have polarities matched to the power input socket on the instrument:

- L = Line or Active Conductor (also called "live" or "hot").
- N = Neutral or Identified Conductor
- E = Earth or Safety Ground

NOTE: Plugs are viewed from connector end. Shape of molded plug may vary within country.

* CSA certification includes only these Power Plugs

Figure 2-2. Power Cord Configurations.

rack mounting; Option 909 adds front handles to the basic rack mount kit. The rack mount kits are designed to permit the Multimeter to be installed in a standard 19 inch rack. When rack mounting, additional support must be provided at the rear of the instrument. Be sure that the air intake at the rear of the instrument is unobstructed.

2-18. Interface Connections.

2-19. The Model 3455A is compatible with the Hewlett-Packard Interface Bus (HP-IB).

NOTE

HP-IB is Hewlett-Packard's implementation of IEEE std 488-1975, "Standard Digital Interface for Programmable Instrumentation".

The Multimeter is connected to the HP-IB by connecting an HP-IB interface cable to the 24-pin connector located on the rear panel. Figure 2-3 illustrates typical HP-IB system interconnections and shows the 10631A/B/C HP-IB Interface Cable connectors. Each end of the cable has both a male and female connector to simplify interconnections of instruments and cables. As many as 15 instruments can be connected by the same interface bus; however, the maximum length of cable that can be used to connect a group of instruments must not exceed 2 meters (6.5 ft.) times the number of instruments to be connected, or 20 meters (65.6 ft.), whichever is less.

2-20. Address Selection. The HP-IB address switch, located on the rear panel, permits the user to set the "talk" and "listen" address of the instrument. The talk and listen address is a 7-bit code which is selected to provide a unique address for each bus instrument. The 3455A normally leaves the factory with the address switch set to a "Listen" address of 6 and a "talk" address of V. The address switch also allows selection of a "talk-only" mode. Refer to Paragraph 3-42 for address selection instructions.

2-21. External Trigger. A BNC connector, located on the rear panel, is provided for an external trigger input. The trigger input is to be driven with TTL level signals.

2-22. ENVIRONMENTAL REQUIREMENTS.

WARNING

To prevent electrical shock or fire hazard, do not expose the instrument to rain or moisture.

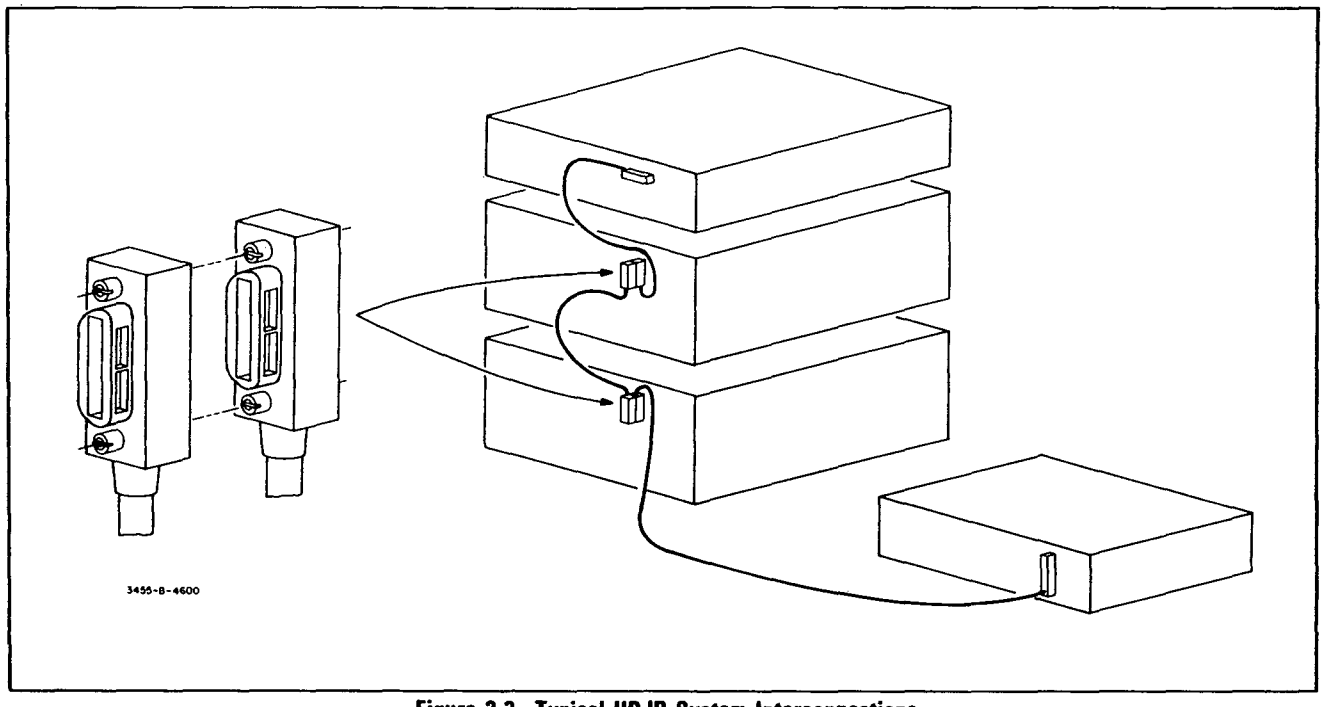


Figure 2-3. Typical HP-IB System Interconnections.

2-23. Operating and Storage Temperature.

2-24. In order to meet the specifications listed in Table 1-1, the instrument should be operated within an ambient temperature range of 23°C ±5°C (73°F ±9°F). The instrument may be operated within an ambient temperature range of 0°C to +55°C (+32°F to +131°F) with degraded accuracy.

2-25. The instrument may be stored or shipped where the ambient temperature range is within −40°C to +75°C (−40°F to +167°F). However, the instrument should not be stored or shipped where temperature fluctuations cause condensation within the instrument.

2-26. Humidity.

2-27. The instrument may be operated in environments with relative humidity of up to 95%. However, the instrument must be protected from temperature extremes which cause condensation within the instrument.

2-28. Altitude.

2-29. The instrument may be operated at altitudes up to 4572 meters (15,000 feet).

2-30. REPACKAGING FOR SHIPMENT.

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished. Include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number and full serial number. If you have any questions, contact your nearest -hp- Sales and Service Office.

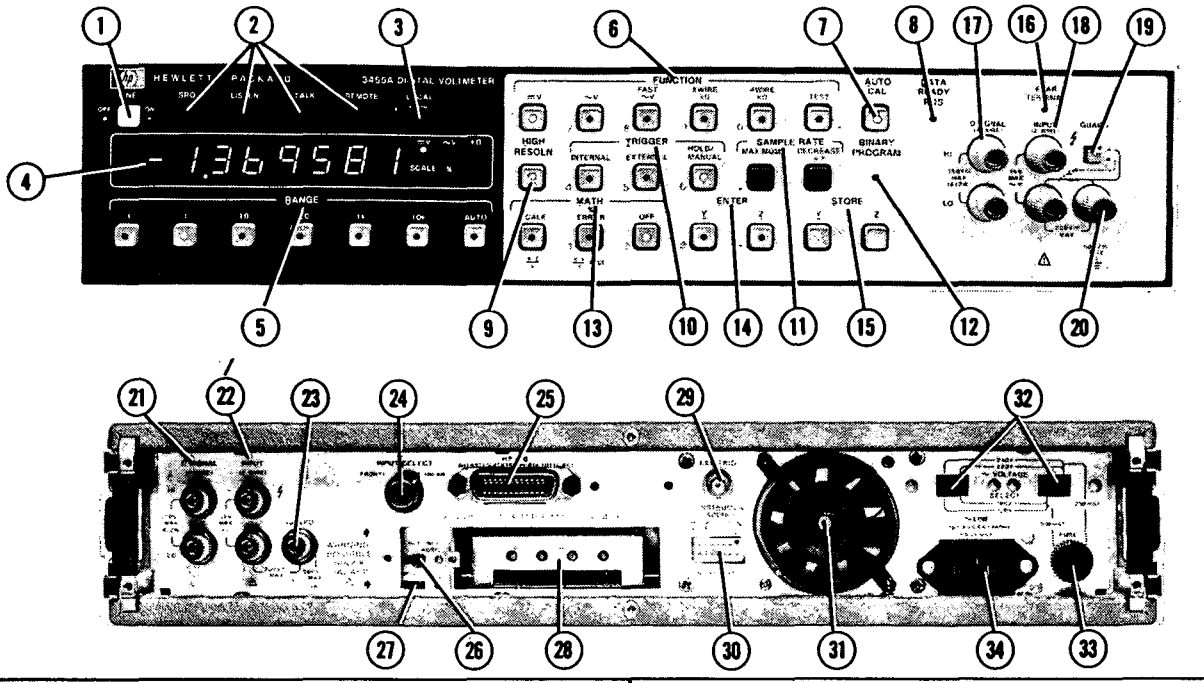
2-31. The following is a general guide for repackaging the instrument for shipment. If the original container is available, place the instrument in the container with appropriate packing material and seal well with strong tape or metal bands. If the original container is not available, proceed as follows:

a. Wrap instrument in heavy paper or plastic before placing in an inner container.

b. Place packing material around all sides of instrument and protect panel face with cardboard strips or plastic foam.

c. Place instrument and inner container in a heavy carton and seal with strong tape or metal bands.

d. Mark shipping container "DELICATE INSTRUMENT", "FRAGILE", etc.



FRONT PANEL

(1) Line Switch, push on/push off

(2) HP-IB* status indicators:
SRQ - indicates that the 3455A "requires service" from the controller. Refer to Paragraph 3-78.
LISTEN – lights when the 3455A is addressed to "listen".
TALK – lights when the 3455A is addressed to "talk".
REMOTE – lights when the 3455A is under HP-IB control.

(3) LOCAL switch – permits the operator to return the instrument to local (front panel) control.

(4) Display – Indicates polarity and amplitude of the measurement. Measurement results are presented in either 5-1/2 digits or 6-1/2 digits depending upon whether the HIGH RESOLUTION feature is off or on. An LED in the upper left corner of the display indicates sample rate of the 3455A. Five LED's, located to the right of the display, indicate whether the display is presenting DC Voltage, AC Voltage, Ohms, Scale or % error measurement results.

(5) Range Selection Keys – permit selection of ranges as follows:
DC Volts: .1 V, 1 V, 10 V, 100 V, 1 kV, AUTO
AC Volts: 1 V, 10 V, 100 V, 1 kV, AUTO
Ohms: .1 K, 1 K, 10 K, 100 K, 1,000 K, 10,000 K, AUTO
LED's located in the center of the keys indicate which range is selected.

(6) Function Selection Keys – DC Volts, AC Volts, FAST AC Volts, 2 WIRE kΩ, 4 WIRE kΩ, and TEST. LED's located in the center of the keys indicate which function is selected.

(7) Auto Cal switch - allows the Auto-Cal feature to be turned on or off. LED in center of Key indicates Auto-Cal on. Refer to Paragraph 3-29.

(8) Data Ready Request Indicator - lights when the Data Ready Request feature is programmed on. Refer to Paragraph 3-65.

(9) High Resolution switch – switches display from 5-1/2 digit presentation to 6-1/2 digit presentation. An LED located in the center of the key indicates High Resolution on when lit.

(10) Trigger Selection Keys – permits selection of INTERNAL, EXTERNAL, or HOLD/MANUAL trigger. Each key has an LED which lights to indicate the trigger source selected.

(11) Sample Rate Controls – permit selection of maximum sample rate or the present sample rate divided by 2. The maximum sample rate may be divided by 2 up to 6 times for a minimum sample rate of: $\frac{\text{maximum sample rate}}{64}$

(12) Binary Program Indicator - indicates when the 3455A is operating in the Binary Program mode. Refer to Paragraph 3-66.

(13) Math Controls – Select SCALE $(\frac{X-Z}{Y})$, % ERROR $(\frac{X-Y}{Y} \times 100)$, or MATH OFF. The Math feature selected is indicated by an LED located in the key (Paragraph 3-19).

(14) ENTER controls - Recall the number stored in the Y or Z register to the display, also "shifts" the front panel keyboard to permit entry of new data to be stored in the Y or Z registers (Paragraph 3-23).

(15) STORE Controls - The Store controls transfer the number presently being displayed into the Y or Z register (Paragraph 3-23).

(16) Rear Terminal Indicator - indicates when the rear input terminals have been selected.

Figure 3-1. Front and Rear Panel Features.

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This section contains information and instructions necessary for operation of the Model 3455A Digital Voltmeter. Included is a description of operation characteristics, a description of the operating controls and indicators, and functional checks to be performed by the operator.

3-3. OPERATING CHARACTERISTICS.

3-4. Turn-On and Warm-Up.

3-5. Before connecting ac power to the 3455A, make certain the rear panel line selector switches are set to correspond to the voltage and frequency of the available power line and that the proper fuse is installed for the voltage selected. For rated measurement accuracy, the 3455A should be allowed to warm up for at least one hour.

3-6. Self Test Operation.

3-7. The internal test function of the 3455A verifies the operation of the dc analog circuitry, inguard and outguard logic circuitry, and the front panel indicators and display. The primary test of the dc analog circuitry is the measurement of various Auto-Cal constants. A logic check is also performed, when all the cal constant measurements are taken. The logic check consists of a dummy cal constant calculation made in the outguard logic of the instrument. When all these measurements and calculations are completed, the 3455A will display +.8.8.8.8.8.8.8. and the self-test operation will start again. In order to bring the instrument out of this mode, any other function button must be pressed.

3-8. In the event of a cal constant failure, the Self-Test operation will stop and the failing cal constant's number will be displayed (an integer number from 13 to 0). If the dummy calculation fails, a non integer number is displayed (e.g., 9.998 or 10.002 etc.).

3-9. The Self-Test function can be remotely programmed, as described in the programming portion of this section. The 3455A will output a 10 upon a successful completion of the test and if addressed to "talk." If the dummy calculation fails, the answer of the dummy calculation will be the output (9.998 or 10.002 etc.). If any auto-cal constants fail, the 3455A will not output any readings, (times out).

NOTE

The self test feature does not test operation of the ohms or ac sections nor the measurement accuracy of the 3455A.

3-10. DC Voltage Measurement.

3-11. The Model 3455A measures dc voltage from 1 microvolt to 1000 volts in five ranges extending from .1

(17) Ohms Signal Terminals - supplies drive signal for 4-WIRE Ohms measurements (Paragraph 3-12).

(18) Input Terminals

(19) GUARD switch - internally connects the Guard terminal to the LO Input terminal (for front panel operation only, Paragraph 3-41).

(20) GUARD Terminal

REAR PANEL

(21) Ohms Signal Terminals

(22) Input Terminals

(23) Guard Terminals

(24) Front/Rear INPUT SELECT switch

(25) HP-IB* Connector - see Paragraph 2-18 and 3-48.

(26) AC or AC/DC Input Selection switch - refer to Paragraph 3-14.

(27) Line Frequency Selection Switch — must be set to correspond to the power line frequency (50 Hz or 60 Hz).

(28) Reference Module

(29) EXTERNAL TRIGGER Input Connector

(30) HP-IB* Address Selection Switch - refer to Paragraph 3-53.

(31) Cooling Fan

(32) Power Line Voltage Selection Switches — refer to Paragraph 2-8.

(33) Fuse — 90 V to 126 V — 0.5 amp, 198 V to 252 V — 0.25 amp.

(34) AC Power Connector.

*HP-IB is Hewlett-Packard's implementation of IEEE Std. 488-1975, "Standard Digital Interface for Programmable Instrumentation".

Figure 3-1. Front and Rear Panel Features (Cont'd).

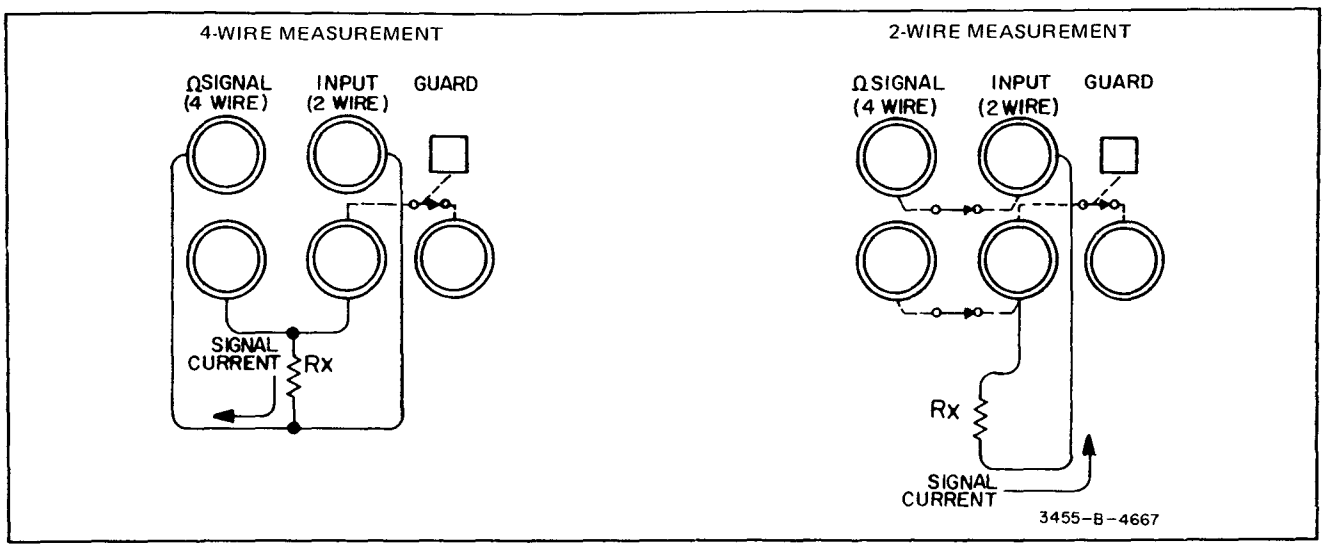


Figure 3-2. Ohmmeter Measurement Connections.

volt full-scale to 1000 volts full-scale. Measurement results are presented in 5-1/2 digits during normal operation or in 6-1/2 digits when the 3455A is set to the High Resolution mode. All ranges except the 1000 volt range have 50% overrange capability and are overload protected from input voltages up to ± 1000 volts. Input resistance in the dc function is greater than 10^{10} ohms on the .1 V, 1 V, and 10 V ranges and equal to 10 megohms on the 100 V and 1000 V ranges. Refer to Table 1-1 for DC Accuracy specifications.

3-12. Resistance Measurement.

3-13. The Model 3455A measures resistance from 1 milliohm to 15 megohms in six ranges extending from .1 kilohms ful scale to 10,000 kilohms full scale. Measurement results are presented in 5-1/2 digits during normal operation or in 6-1/2 digits when the 3455A is set to the High Resolution mode. The only exception is that the .1 V range can only take a measurement in the 5-1/2 digit mode. Resistance may be measured in "4-WIRE" configuration for optimum accuracy or "2-WIRE" configuration may be selected for measurement convenience. Figure 3-2 shows proper connections for making resistance measurements. The nominal output signal current on the .1 kilohm, 1 kilohm and 100 kilohm ranges is .7 mA. The nominal output current on the 1000 kilohm and 10,000 kilohm ranges is .7 microamp. Maximum output voltage is limited to less than 5 volts on all ranges. Refer to Table 1-1 for ohm accuracy specifications.

3-14. AC Voltage Measurement.

3-15. The -hp- Model 3455A offers a choise of true RMS (standard unit) or average responding ac convertors (Option 001). Both methods measure ac voltages from 10 microvolts to 1000 volts in four ranges extending from 1 volt to 1000 volts ranges. All ranges, except the 1000 volts range, have 50% overrange capability and are protected from input voltage components up to 1000 volts RMS. Readings taken in the ac function are display in the 5-1/2 digit mode only. Input impedance of both convertors is 2 megohms in parallel with < 75 pF for rear terminal input and < 90 pF for front terminal input. In addition to the normal ac volts function, the 3455A also has a fast ac volts function. The fast ac function has a faster ac reading rate than the normal ac function.

3-16. The frequency response of the true RMS convertor is from 30 Hz to 1 MHz in the normal ac volts function and from 300 Hz to 1 MHz in the fast ac volts function. Both ac signals or ac plus dc signals (ac signals superimposed on a dc level) can be measured by the true RMS convertor. Selection of the ac or ac + dc inputs are chosen by a switch located behind the rear panels reference cover. Refer to Table 1-1 for accuracy specifications of each ac mode.

3-17. The frequency response of the average converter is from 30 Hz to 250 Hz in the normal ac volts function and from 300 Hz to 250 kHz in the fast ac volts function. Only ac signals (no dc component) can be measured by the average converter. Refer to Table 1-1 for accuracy specification of each ac mode.

3-18. In order to get accurate ac readings (especially with high voltage inputs at high frequencies), the low input terminal (front and rear) should be connected to the guard terminal (front and rear). Refer to paragraph 3-39 for guarding information.

NOTE

The front panel guard pushbutton applies only for front panel inputs. Be sure to wire rear panel guard connections yourself, if using the rear panel input terminals.

3-19. Math Feature.

3-20. The math feature of th 3455A allows the measurement value to be offset and/or scaled by known values or to be expressed in percent of a reference value.

3-21. Scale Mode. The scale mode of the math feature is described by the formula: result = $\frac{x-z}{y}$ where x is the measurement value, z is the offset value, and y is the scale factor. This mode allows the measurement value to be modified by the addition, subtraction, multiplication or division of a known value. Addition and subtraction are performed by entering the number to be added or subtracted in "z" and entering 1 in "y". The scale formula then becomes: result = $\frac{x-(\pm z)}{1} = x-(\pm z)$. Division is performed by entering Ø in "z" and the divisor value in "y." The scale formula then becomes: result = $\frac{x-Ø}{y} = \frac{x}{y}$. Multiplication is performed by dividing the measurement value by the inverse of the multiplier value; that is, multiplication is performed by dividing by a fraction. The scale formula becomes: result = $\frac{x-Ø}{1/y} = xy$. As an example: to multiply by 10, divide by the inverse of 10 which is 1/10 or .1. Various examples using the scale mode are as follows:

a. *Current Measurement:* Accurate current measurements can be made by using a low value resistor shunting the 3455A's input terminals. The value of the resistor is then entered in the "y" register (see Paragraph 3-22), and zero is entered in the "z" register With the resistor connected at the input terminal and the instrument set in the voltage mode, current measurements can now be made. You can do this by connecting the input across the resistor and measuring the voltage drop across the resistor. This voltage drop is proportional to the current through the resistor. By switching the 3455A to the scale mode, the reading becomes an accurate current reading in milliamps. Since the resistor value is in kilo ohms (R) and stored in "y", and since zero is stored in "z", the scale equation becomes:

$$\frac{x-z}{y} = \frac{V-0}{R} = \frac{V}{R} = \text{current in milliamps}$$

where R = Resistor across the input terminals
V = Voltage drop across the resistor

b. *Temperature Measurement:* A temperature measurement can be made by using a line or resistive temperature sensor.

Assume that the sensor has a resistance of 1 kilohm at 25°C and changes 5900 ppm/°C. At Ø°C the sensor would have a resistance of 852.5 ohm (1 kilohm - [5.9 ohms] 25). This number is divided by 1000 since the 3455A measurement results are expressed in kilohm and is entered in the "z" register to remove the offset at 0°C. The measurement result of the 3455A is scaled to read directly in degrees centigrade by solving the equation for the value of "y". This is done where the results of the equation are equal to 25°C since the sensor resistance is specified at that temperature. The scale equation becomes:

$$25 = \frac{x-z}{y} = \frac{1\text{ K} - .8525\text{ K}}{y} = \frac{.1475\text{ K}}{y}$$

solving for y: $y = \frac{.1475\text{ K}}{25} = .0059$ with this number entered in the "y" register, the 3455A measurement result will be presented directly in °C.

c. *Accurate 2 Wire Ohm Measurement:* When trying to make an accurate 2 wire ohm measurement, the input lead resistance and the internal resistance of the 3455A should be subtracted out from the reading. This is done by setting the instrument to the desired range and short the input leads at the measuring point. Store a 1 in "y" and store the input lead resistance reading in "z". Open the input leads and connect the unknown resistor to the leads. With the 3455A set in the Scale mode, the value of the unknown resistor is displayed without the input lead resistance. Since a 1 is stored in "y" and the lead resistance (R) is stored in "z", the scale equation becomes:

$$\frac{x-z}{Y} = \frac{x-R}{1} = \text{unknown resistance in ohms}$$

where x = total measured resistance including R
R = lead resistance

d. *Limit Testing:* The Scale mode of the 3455A can also be used to do Limit Testing. This can be accomplished since the largest number which can be displayed is +200,000 and the smallest number is -200.00. If the magnitude of the display exceeds 200,000, either a "+LL" or a "-LL" is displayed. Therefore, the "y" and "z" constants must be chosen so that when "x" (the reading) is equal to the upper limit, the display is +200,000 and when "x" is equal to the lower limit, the display is -200,000. This can be accomplished as follows:

When x = the Lower Limit, the DISPLAY should = -200,000

When x = the Upper Limit, the DISPLAY should = +200,000

$$\text{therefore, } -200{,}000 = \frac{\text{Lower Limit} - z}{y}$$

$$\text{and} \quad +200{,}000 = \frac{\text{Upper Limit} - z}{y}$$

This leaves two equations to solve for the unknown "y" and "z" constants. The two constants can be found the following way:

$$\begin{aligned} -200{,}000\,(y) &= \text{Lower Limit} - z \\ +200{,}000\,(y) &= \text{Upper Limit} - z \\ \hline 0 &= \text{Lower Limit} + \text{Upper Limit} - 2Z \\ & \quad \text{(add these two equations)} \end{aligned}$$

$$\text{therefore, } z = \frac{\text{Upper Limit} + \text{Lower Limit}}{2}$$

$$200{,}000 = \frac{\text{Upper Limit} - z}{y}$$

$$200{,}000\,(y) = \text{Upper Limit} - \frac{\text{Upper Limit} + \text{Lower Limit}}{2}$$

$$= \frac{\text{Upper Limit} - \text{Lower Limit}}{2}$$

$$\text{and, } \quad y = \frac{\text{Upper Limit} - \text{Lower Limit}}{400{,}000}$$

The following is an example of how to use this math technique. In this example a DC voltage is measured and compared with a Lower Limit of 10 volts and an Upper Limit of 30 volts:

$$y = \frac{\text{Upper Limit} - \text{Lower}}{400{,}000} = \frac{30 - 10}{400{,}000} = .00005$$

$$z = \frac{\text{Upper Limit} + \text{Lower Limit}}{2} = \frac{30 + 10}{2} = 20$$

By entering .00005 into the "y" register and 20 into the "z" register, and then pushing the SCALE and DCV buttons, the 3455A becomes a limit testing DVM. If the input exceeds 30 volts a "+ LL" is displayed, and if the input is less than 10 volts a "-LL" is displayed. If the input is within the limits set, a number is displayed.

3-22. % Error Mode. The % error mode of the math feature is described by the formula: result in $\% = \frac{x-y}{y} x$ 100, where "x" is the present measurement value and "y" is the reference value. An application of this feature might be an inspection test of resistors. This nominal resistor value would be entered in the "y" register in kilohm (3455A) resistance measurements are presented in kilohm). As an example, assume the test is made on a group of 750 ohm resistors with a tolerance of 5%. The nominal resistor value (750 ohms) is entered in the "y" register as .750. The % error equation becomes: result in $\% = \frac{x-.750}{.750} \times 100$. A resistor with an actual value of 790 ohms would give a measurement result of: $\%\ \text{error} = \frac{.790-750}{750} \times 100 = 5.33333\%$, indicating the resistor is out of tolerance by .33333%.

3-23. Enter and Store.

3-24. The "Y" and "Z" ENTER keys have two functions. When one of the enter keys is pressed, the number presently stored in the respective memory register is displayed on the front panel readout. This allows the operator to check the contents of the "Y" or "Z" memory registers. Pressing the enter key also "shifts" the front panel keyboard, disabling all keys except those labeled in blue. These keys can now be used to enter the desired values to be stored in the "Y" or "Z" memory registers. As the value is entered it is displayed on the front panel readout. Numerical values from .000000 to + or - 199,999.9 may be entered in either the Y or Z registers.

3-25. The STORE keys are used to transfer the number presently being displayed in the "Y" or "Z" memory registers and to return the voltmeter to normal operation.

3-26. The following describes how the ENTER and STORE features may be used:

a. To view the value presently in memory, press the ENTER key of the appropriate register (ENTER Y or ENTER Z). To return this number to memory, press the STORE key of the appropriate register.

b. To enter a new number, press the ENTER key of the register to receive the number. Enter the desired number into the display by pressing the keys labeled in blue. Store the number entered by pressing the STORE key of the appropriate register.

c. To enter a measurement value presently being displayed, press the STORE key of the desired register (Y or Z).

NOTE

The operation of the ENTER and STORE keys are not mutually exclusive. That is, the number being displayed may be stored in either the Y or Z register independently of the register selected by the ENTER keys.

3-27. High Resolution Mode.

3-28. When the 3455A is used in the HIGH RESOLUTION mode, the instrument changes from a 5-1/2 digit measurement to a 6-1/2 digit measurement. This changes the measurement resolution from 10 parts/1.5 million (5-1/2 digit mode) to 1 part/1.5 million (6-1/2 digit mode). The integration period will also change from 1/60 second (1/50 second for 50 Hz operation) to 8/60 second (8/50 second for 50 Hz operation). The High Resolution mode cannot be used in the AC mode or the .1 V DC and 1 K ohm ranges. The reading rate in the DC and Ohms mode will also increase when the High Resolution function is turned off. Table 3-1 gives the various reading rates of the DC and Ohms functions

with High Resolution turned on or off.

3-29. Auto-Cal.

3-30 The purpose of the AUTO-CAL feature is to eliminate offsets, gain non-linearity, and drift which maybe present in the analog measuring circuits of the 3455A. This is accomplished by measuring the offset and gain errors and then mathematically correcting the measurement reading to exclude them. Each of the gain and error measurements, called Auto-Cal constants, are stored in the "memory" by the 3455A's main controller. These Auto-Cal constants are usually taken between each sample of the instrument and are updated each time a new cal constant measurement is made.

3-31. The reading rate of the 3455A increases when the Auto-Cal feature is turned off. Table 3-1 gives the reading rate of the various functions with Auto-Cal on or off.

3-32. The last set of constants are used to correct measurements, when the Auto-Cal mode is turned off. As long as the input amplifier offsets, gain linearity and drift do not vary the 3455A should remain within it's accuracy specifications. The time period over which these parameters will not change may vary from instrument to instrument. When the Auto-Cal function is disabled to obtain faster reading rates, it is recommended to periodically return the 3455A to the Auto-Cal mode in order to update the cal constants. This can be done after a block of readings have been taken or when the instrument is not in use. The instrument will then update the cal constants for accurate measurements. Allow about 6 seconds for updating the cal constants, if the 3455A is in the Hold mode.

3-33. Trigger.

3-34. The 3455A has three trigger modes. INTERNAL, EXTERNAL, and HOLD/MANUAL. The following is an explanation of each trigger mode.

a. *Internal Trigger:* This trigger is generated internally and triggers the 3455A to take a reading, after the previous operation is completed (a reading or Auto-Cal measurement). This trigger mode is entered when the instrument is turned on, when the Internal Trigger button is pressed, or a Device Clear message is remotely sent.

b. *External Trigger:* When the 3455A is the External Trigger mode, the user can trigger the instrument from an external trigger pulse. This trigger pulse has to be applied to the rear External Trigger Connector and should have a negative TTL edge and must be at least 3 seconds wide. The instrument will take a measurement, when this trigger pulse is received. After the measurement is taken, the 3455A can be triggered again for a new reading. If the instrument is triggered while making a measurement, the new trigger is delayed. After the first measurement cycle is completed, the delayed trigger will iniate a second measurement cycle. Only one trigger will be delayed during any given measurement cycle. Any extra triggers sent during this cycle will be ignored.

c. *Hold/Manual Trigger:* This trigger is similar to the External Trigger, except it can be executed by the Hold/Manual button. The Hold/Manual button must be pressed once in order to place the 3455A in the Hold mode. After pressing the Hold/Manual button the second time, a measurement is taken. When the measurement cycle is completed, the Hold/Manual button can be pressed again for a new reading. It is important to remember that the Hold/Manual button should be pushed twice in order to take the first reading. If triggered while a measurement is taken, the trigger is delayed until the measurement cycle is complete. The delayed trigger will initiate a second measurement cycle, when the first one is completed. Only one trigger will be delayed during any given measurement cycle. Any extra triggers sent during this cycle will be ignored.

3-35. Auto-Cal constants measurements also depend on the Trigger mode used. An input reading and a cal constant measurement will alternately be taken, when the 3455A is in the Internal Trigger mode. A typical sequence would be an input reading, one cal constant measurement, another input reading, the next cal constant measurement, and so on. An attempt of this sequence (input reading/cal Constant measurement) is also made when the instrument is in the Hold/Manual or External Trigger modes. If, however, a trigger is received while a cal constant measurement is taken, this measurement is aborted and an input reading is taken. After this reading, the aborted cal constant measurement is then retaken. If a new trigger is received before the cal constant measurement is finished, the measurement is again aborted and a new input reading is taken. The cal constant measurement can be aborted a number of times, depending on the function of the instrument. The table below lists the number of times the cal constant measurements can be aborted. After this number has been reached, the trigger will be delayed and the Auto-Cal constant measurement is then completed.

Function	Maximum Number of Cal Constant Termination
DC	128
DC (High Resolution)	32
AC Fast	64
AC Normal	8
Ohms	64
Ohms (High Resolution)	16

These numbers are accumlative when Auto-Cal is on.

3-36. Sample Rate (Display).

3-37. The SAMPLE RATE of the 3455A is set internally and depends on the function selected, the power line

frequency, and use of the Auto-Cal and High Resolution modes. When the Sample Rate buttons are pressed, the display rate of the reading are changed. By depressing the Decrease ÷ 2 button on the front panel, the display rate can be decreased. Each time this button is pressed, the display rate is divided by two. The rate may be divided a maximum of six times for a display rate of 1/64 of the maximum rate. The 3455A can be reset to the maximum rate by depressing the maximum button, after the display rate has been decreased. Table 3-1 gives the maximum number of readings the instrument can display on the front panel, in local operation.

Table 3-1. Maximum Front Panel Reading Rates.

Func Function	High Resolution	Auto Calibration	Maximum Sample Rate Maximum Sample Rate
DC Volts	ON	ON	3 readings/sec (60 Hz) 2.5 readings/sec (50 Hz)
	OFF	ON	5 readings/sec (60 Hz) 3.5 readings/sec (50 Hz)
	ON	OFF	6 readings/sec (60 Hz) 5 readings/sec (50 Hz)
	OFF	OFF	24 readings/sec (60 Hz) 22 readings/sec (50 Hz)
Ohms	ON	ON	2 readings/sec (60 Hz) 1.8 reading/sec (50 Hz)
	OFF	ON	45 readings/sec (60 Hz) 4 readings/sec (50 Hz)
	ON	OFF	3 readings/sec (60 Hz) 2.5 readings/sec (50 Hz)
	OFF	OFF	12 readings/sec (60 Hz) 11 readings/sec (50 Hz)
AC Volts	Not Applicable	ON	1.3 readings/sec (60 Hz) 1.1 readings/sec (50 Hz)
	Not Applicable	OFF	1.3 readings/sec (60 Hz) 1.1 readings/sec (50 Hz)
Fast AC Volts	Not Applicable	ON	4.5 readings/sec (60 Hz) 3.5 readings/sec (50 Hz)
	Not Applicable	OFF	13 readings/sec (60 Hz) 12 readings/sec (50 Hz)

3-38. Auto Range.

3-39. The AUTO RANGE feature of the 3455A can be used to automatically uprange and downrange the instrument to the optimum range. This action takes place when an input measurement is taken. Upranging is done when the reading is 150% of full scale and downranging at 14% of full scale. The Auto Range operation can be observed by applying 1.4 volts to the input of the 3455A. The range selected by the instrument is the 1 V range. When the input voltage exceeds 1.5 volts, the 3455A upranges to the 10 V range. When the input voltage is decreased below 1.4 volts, the 1 V range is again selected. The uprange points, the downrange points, and the accuracy of the instrument should be kept in mind when making a measurement. Time-varient inputs may cause the 3455A to constantly uprange and downrange. If this happens, manually set the instrument to the higher range.

3-40. Measurement time may also change, when the instrument is in the Auto Range mode. If the instrument is not on the optimum range, a reading is taken and the 3455A will either uprange or downrange. Another reading is then taken and if the optimum range has been found the reading will be displayed. If not, the instrument continues to uprange or downrange. A reading is taken on all intermediate non-optimum ranges until the correct range is found. The measurement time on each range should be added to the total measurement time.

3-41. GUARDING.

3-42. Common-Mode Voltages.

3-43. Common-mode voltages are those which are generated between the power line ground point of the source and the LO input and power line ground point of the 3455A. Currents caused by common-mode voltage can be included in the measurement circuit, causing measurement errors.

3-44. Guard Connection.

3-45. Figure 3-3 illustrates three methods of connecting the 3455A Guard terminal to reduce errors caused by common-mode voltages. In example A, Guard is at nearly the same potential as the LO measurement terminal so that currents caused by common-mode voltage flows through Guard and not the measurement circuit. In example B, the 3455A guard switch is closed connecting guard to the LO input terminal. This allows common-mode current to flow through lead resistance R_b causing some measurement error. This connection may be used if common-mode voltages are not expected to be a problem. Example C is similar to A with the exception that connecting guard in this manner allows any common-mode current generated between the source low and powerline ground to flow in the measurement circuit.

NOTE

The front panel guard pushbutton applies only for front panel inputs. Be sure to wire rear panel guard connections yourself, if-using the rear panel input terminals.

3-46. Guarding Information.

3-47. More detailed information on purpose and methods of guarding may be found in -hp- Application Note No. 123, "Floating Measurements and Guarding". This application note is available through your nearest -hp- Sales and Service Office.

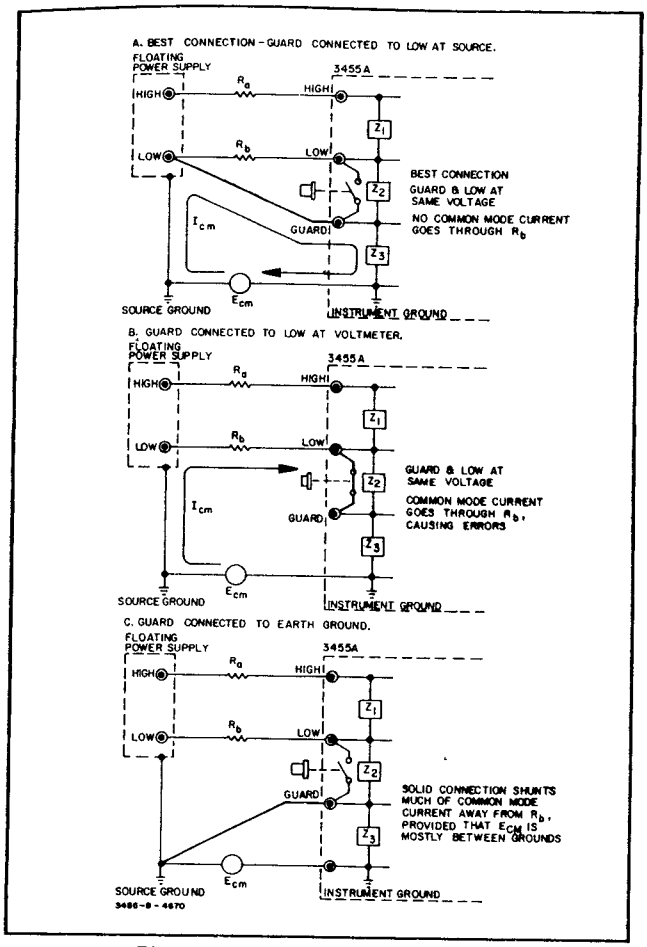


Figure 3-3. Connecting the Guard.

CAUTION

Guard should always be connected, either to the instrument LO terminal or to a point in the source circuit as indicated in Figure 3-3. If the guard terminal is left open, common-mode voltages may exceed the LO-to-Guard breakdown rating and damage the instrument.

3-48. REMOTE OPERATION.

3-49. General.

3-50. The Model 3455A is remotely controlled by means of the Hewlett-Packard Interface Bus (HP-IB). The HP-IB is a carefully defined instrumentation interface which simplifies the integration of instruments, calculators, and computers into systems.

NOTE

HP-IB is Hewlett-Packard's implementation of IEEE Std. 488-1975, "Standard Digital Interface for Programmable Instrumentation."

3-51. The capability of a device connected to the Bus is specified by the interface functions it has. Table 3-2 lists the Interface Functions included in the Model 3455A. These functions are also listed above the rear panel HP-IB connector (see Figure 3-1). The number following the interface function code indicates the particular capability of that function as listed in Appendix C of IEEE Std. 488-1975.

Table 3-2. HP-IB Interface Capability.

Code	Interface Function
SH1	Source Handshake capability
AH1	Acceptor Handshake Capability
T5	Talker (basic talker, serial poll, talk only mode, unaddress to talk if addressed to listen)
L4	Listener (basic listener, unaddress to listen if addressed to talk)
SR1	Service Request Capability
RL1	Remote/Local Capability
PP0	No Parallel Poll Capability
DC1	Device Clear Capability
DT1	Device Trigger Capability
C0	No Controller Capability
E1	Open Collector Bus Drivers

Interface Functions provide the means for a device to receive, process and send messages over the bus.

3-52. Messages are the means by which devices exchange control and measurement information. These messages permit communication and/or control between:

Controller and Device(s)
Device and Device(s)
Controller and Controller(s)

Table 3-3 lists the Bus Messages and gives a brief description of each. The messages are categorized by Bus function.

3-53. Address Selection.

3-54. The "talk" and "listen" addresses of the 3455A are selected by the INSTRUMENT ADDRESS switch. This switch is a seven section "Dip" switch located on the rear panel (see Figure 3-1). The five switches, labeled 1 through 5 are used to select a unique talk and listen address. Figure 3-4 lists the available address codes and the corresponding switch settings. The 3455A normally leaves the factory with the switch set to listen address 6 and talk address V (decimal code 54).

3-55. Talk Only (No Controller). The 3455A may be used to provide measurement data to another device, such as a printer, without having a controller on the Bus. However, the device must be HP-IB compatible. The talk only switch must be set to the TALK ONLY position. In this mode the 3455A will output measurement

Table 3-3. Bus Messages.

Functions	Message	Description
Device Communications	Data	Transfers device-dependent information from one device to one or more devices on the Bus.
Device Control	Trigger	Causes a group of selected devices to simultaneously intitate a set of device-dependent actions.
	Clear	Causes an instrument to be set to a pre-defined state (a certain range, function, etc.).
	Remote	Permits selected devices to be set to remote operation, allowing parameters and device characteristics to be controlled by Bus Messages.
	Local	Causes selected devices to return to local (front panel) operation.
	Local Lockout	Disables local (front panel) controls of selected devices.
	Clear Lockout and Local	Returns all devices to local (front panel) control and simultaneously clears the Local Lockout Message.
Interrupt and Device Status	Require Service	Indicates a device's need for interaction with the controller.
	Status Byte	Presents status information of a particular device; one bit indicates whether or not the device currently requires service, the other 7 bits (optional) are used to indicate the type of service required.
	Status Bit	A single bit of device-dependent status information which may be logically combined with status bit information from other devices by the controller.
Passing Control	Pass Control	Passes bus controller responsibilities from the current controller to a device which can assume the Bus supervisory role.
Bail Out	Abort	Unconditionally terminates Bus communications and returns control to the system controller.

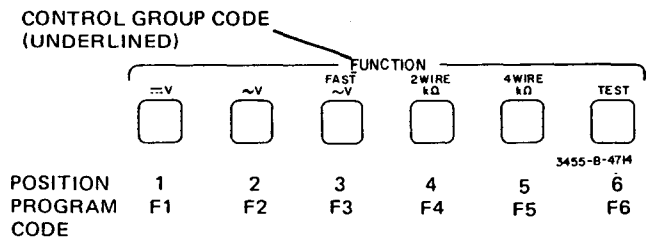
data each time a measurement sample is made. Section of FUNCTION, RANGE, TRIGGER, etc. is accomplished manually using the front panel controls.

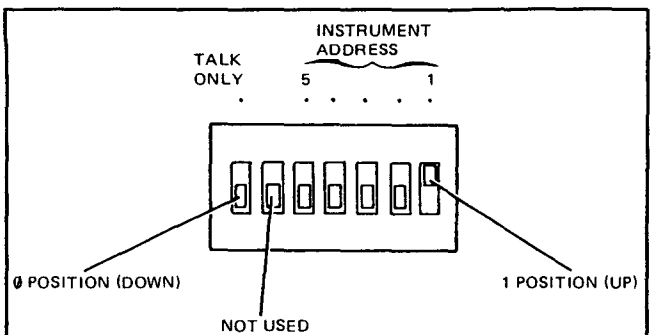
NOTE

When the 3455A is connected to a system with a controller, the TALK ONLY switch must be set to the off position.

3-56. Program Codes.

3-57. All front panel controls, except the LINE switch, GUARD switch, and SAMPLE RATE switches, are programmable from the Bus. The program codes for each control are listed in Table 3-4. The program codes can also be determined from the front panel markings. For multi-control features such as FUNCTION, RANGE, TRIGGER, and MATH the program code consists of the combination of the underlined letter in the control group heading and the position number of the particular control. See the following example:





ASCII Code Character		Address Switches					5-bit
Listen	Talk	A5	A4	A3	A2	A1	Decimal Code
SP	@	0	0	0	0	0	00
!	A	0	0	0	0	1	01
"	B	0	0	0	1	0	02
#	C	0	0	0	1	1	03
$	D	0	0	1	0	0	04
%	E	0	0	1	0	1	05
&	F	0	0	1	1	0	06
'	G	0	0	1	1	1	07
(	H	0	1	0	0	0	08
)	I	0	1	0	0	1	09
*	J	0	1	0	1	0	10
+	K	0	1	0	1	1	11
,	L	0	1	1	0	0	12
-	M	0	1	1	0	1	13
.	N	0	1	1	1	0	14
/	O	0	1	1	1	1	15
0	P	1	0	0	0	0	16
1	Q	1	0	0	0	1	17
2	R	1	0	0	1	0	18
3	S	1	0	0	1	1	19
4	T	1	0	1	0	0	20
5	U	1	0	1	0	1	21
6	V	1	0	1	1	0	22
7	W	1	0	1	1	1	23
8	X	1	1	0	0	0	24
9	Y	1	1	0	0	1	25
:	Z	1	1	0	1	0	26
;	[	1	1	0	1	1	27
<	\	1	1	1	0	0	28
=	]	1	1	1	0	1	29
>	~	1	1	1	1	0	30

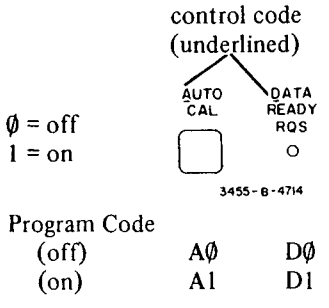
Figure 3-4. Address Selection.

Table 3-4. HP-IB Program Codes.

	Control	Program Code
FUNCTION	DC Volts	F1
	AC Volts	F2
	Fast AC Volts	F3
	2 Wire kΩ	F4
	4 Wire kΩ	F5
	Test	F6
RANGE	.1	R1
	1	R2
	10	R3
	100	R4
	1 K	R5
	10 K	R6
	AUTO	R7
TRIGGER	Internal	T1
	External	T2
	Hold/Manual	T3
MATH	Scale	M1
	Error	M2
	Off	M3
ENTER	Y	EY
	Z	EZ
STORE	Y	SY
	Z	SZ
AUTO CAL	Off	AØ
	On	A1
HIGH RESOLUTION	Off	HØ
	On	H1
DATA READY RQS	Off	DØ
	On	D1
BINARY PROGRAM		B

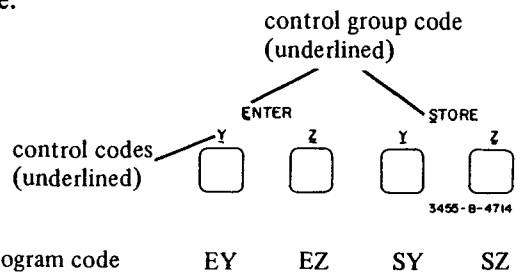
3-58. The program code for single control features which can only be programmed on or off (AUTO CAL and HIGH RESOLUTION) consist of the letter underlined in the control heading and the number "Ø" for off or the number "1" for on. This also applies to the DATA READY Request feature which is Bus programmable only.

Example:



3-59. Program codes for the ENTER and STORE features consist of the letter underlined in the control heading and the underlined letter of the particular control.

Example:



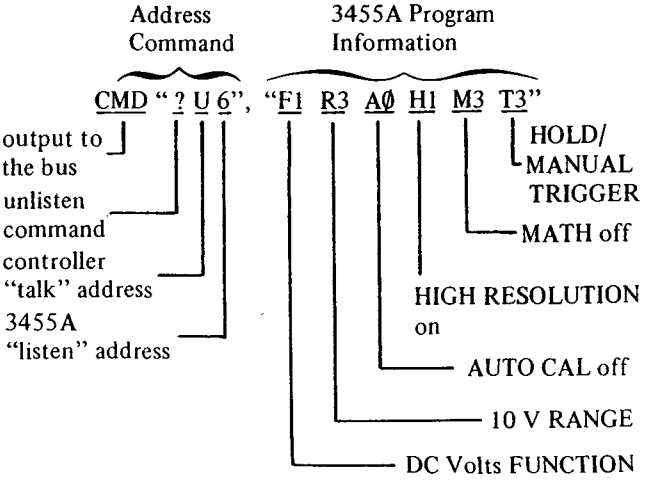
3-60. The program code of the BINARY PROGRAM feature consists of only the underlined character in the control heading (B).

3-61. Data Messages.

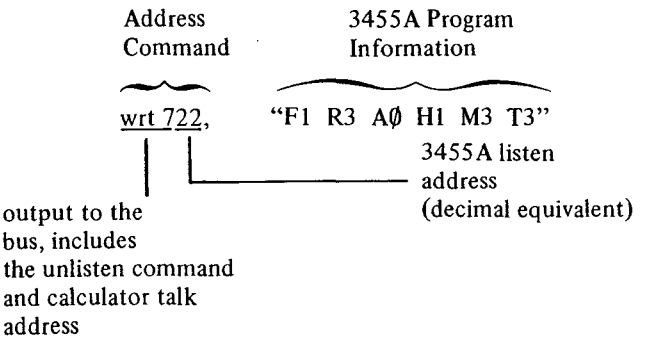
3-62. The major portion of communications transmitted over the Bus is accomplished by data messages. Data messages are used by the controller to program the Model 3455A and are used by the 3455A to transmit measurement data. These functions are explained in the following paragraphs.

3-63. Programming. The 3455A is programmed by means of data messages sent over the Bus from the controller. These messages are composed of two parts — the address command and the program information. The address command contains the "talk" and "listen" addresses of the devices involved; in this case, the talk address of the controller and the listen address of the 3455A. The program information contains the codes of the 3455A controls to be programmed. Syntax of the address command portion of the data message is dependent upon the controller being used. For the proper syntax refer to the controller manual. Syntax for the program information portion consists of the program codes listed in Table 3-4.

Example program data messages:

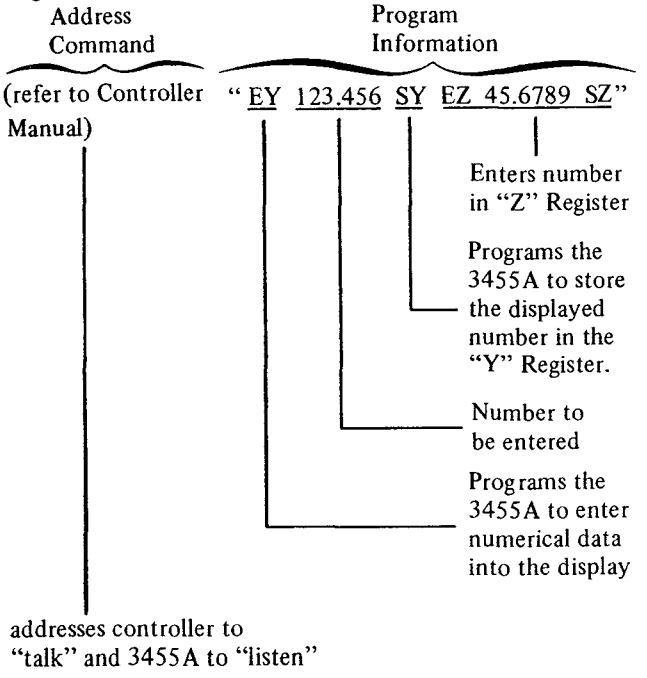


Program data message using the 9830A Calculator.

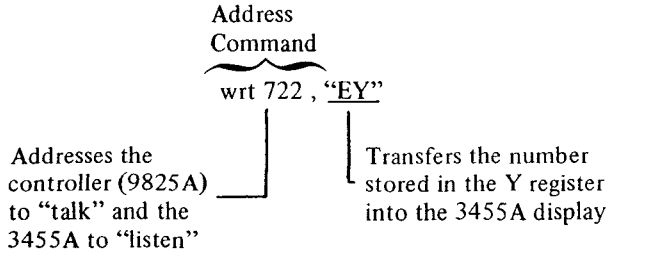


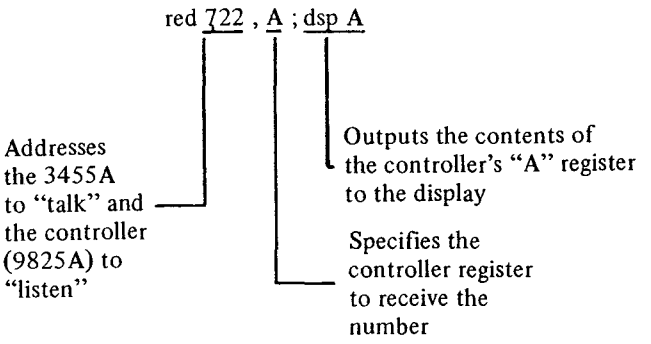
Program data message using the 9825A Calculator.

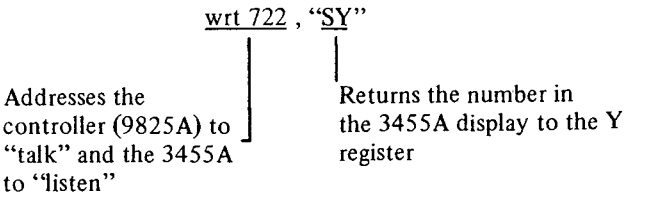
3-64. Entering MATH Constants (Y and Z) from the Bus. The following data message illustrates the program information necessary to enter numbers into the Y and Z registers:



The number stored in the Y or Z register can be read from the Bus by programming the ENTER feature and the particular register. This transfers the number from the storage register specified to the display. The number displayed is output to the Bus by addressing the 3455A to "talk". The number is returned to the storage register by programming the STORE feature and the desired register. The following example illustrates how to read the numbers stored in the Y and Z register from the Bus:







3-65. Data Ready Request. The DATA READY Request feature permits the 3455A to signal the controller upon the completion of a measurement. This feature would normally be used where the 3455A is triggered from an external source. In this mode of operation, the 3455A is programmed to the appropriate measurement parameters (FUNCTION, RANGE, etc.). The controller is then free to control other instruments on the Bus. Upon being triggered, the 3455A makes a measurement and outputs a "Require Service" message to notify the controller that the measurement information information is ready. Upon receiving the service request, the controller with serial poll the 3455A to determine the nature of the service request. Upon being polled, the 3455A outputs a status byte, in this case the ASCII character "A" (decimal 65), indicating the measurement data is ready. The controller then disables the serial poll and reads the measurement data. The program codes for the DATA READY RQS feature are:

DØ Data Ready Request off
D1 Data Ready Request on

3-66. Binary Program Feature. The BINARY PROGRAM feature permits the status of the FUNCTION, RANGE, TRIGGER, MATH, AUTO-CAL and HIGH RESOLUTION controls to be determined or programmed from the bus in four 8-bit binary words. The BINARY PROGRAM feature allows faster programming of the 3455A by reducing the number of program data bytes from a maximum of 12 for normal programming to 4 data bytes for binary programming. The BINARY PROGRAM codes can also be read and stored by the controller to re-program the 3455A at a later time (see Appendix A). One important thing to remember is to send a "B" to the 3455A in order to put the instrument into the BINARY mode. Table 3-5 lists the allowable BINARY PROGRAM codes for each of the four data bytes and the front panel keys they control.

3-67. The following data message examples illustrate how to read or program the front panel control of the 3455A. To read control status:

wrt 722, "B"

Address the 3455A to "listen"

Set the 3455A to the BINARY PROGRAM mode

Since normally four data bytes are used in Binary programming, the 3455A may indicate an SRQ condition when only a "B" is sent.

red 722

Address the 3455A to "talk"

The 3455A, after receiving the "talk" command, will output the front panel control status codes (4 bytes). As an example, if the front panel controls were in the "turn-on" state, the 3455A would output the following codes:

; N = >

MATH OFF

DC Volts FUNCTION

AUTO CAL ON
AUTO RANGE ON
HIGH RESOLUTION OFF
INTERNAL TRIGGER

1 Volt RANGE
(depends on input applied)

To program front panel controls:

wrt 722, "B ;K/="

Address the 3455A to "listen"

Desired program codes (see Table 3-5)

Set 3455A to BINARY PROGRAM mode

Table 3-5. BINARY PROGRAM Codes.

First BINARY PROGRAM Data Byte

Controls Affected: SCALE, % ERROR, OFF (MATH)

To Program:	Program Code ASCII CHAR	Program Code DECIMAL CODE
OFF	;	59
% ERROR	=	61
SCALE	>	62

Second BINARY PROGRAM Data Byte

Controls Affected: AUTO CAL, AUTO RANGE, HIGH RESOLUTION, HOLD/MANUAL, EXTERNAL, INTERNAL

To Program: AUTO CAL	AUTO RANGE	HIGH RESOLUTION	TRIGGER	PROGRAM CODE ASCII CHAR	PROGRAM CODE DECIMAL CODE
Off	Off	Off	Hold/Manual	;	59
			External	=	61
			Internal	>	62
Off	Off	On	Hold/Manual	3	51
			External	5	53
			Internal	6	54
Off	On	Off	Hold/Manual	+	43
			External	–	45
			Internal	.	46
Off	On	On	Hold/Manual	#	35
			External	%	37
			Internal	&	38
On	Off	Off	Manual/Hold	[	91
			External	]	93
			Internal	^	94
On	Off	On	Manual/Hold	S	83
			External	U	85
			Internal	V	86
On	On	Off	Manual/Hold	K	75
			External	M	77
			Internal	N	78
On	On	On	Manual/Hold	C	67
			External	E	69
			Internal	F	70

Third BINARY PROGRAM Data Byte

Controls Affected: 10 K, 1 K, 100, 10, 1, .1 (RANGE)

To Program:	Program Code ASCII CHAR	Program Code DECIMAL CODE
10 K	–	95
1 K	/	47
100	7	55
10	;	59
1	=	61
.1	>	62

Fourth BINARY PROGRAM Data Byte

Controls Affected: TEST, 4 WIRE kΩ, 2 WIRE kΩ, FAST ACV, ACV, DCV (FUNCTION)

To Program:	Program Code ASCII CHAR	Program Code DECIMAL CODE
TEST	–	95
4 WIRE kΩ	/	47
2 WIRE kΩ	7	55
FAST ACV	;	59
ACV	=	61
DCV	>	62

3-68. Measurement Data. Measurement data is output by the 3455A in the following general format:

OUTPUT FORMAT: ± D.DDDDDDE ± DD CRLF

Polarity of measurement (does not apply to ACV or OHM measurements)

Measurement reading expressed in scientific notation

Terminates message

This format is printed in the lower left corner of the 3455A front panel for convenience. The following is an example of a data message output by the 3455A:

Input to 3455A: -143.5 volts DC
Output Data Message: -1.435000 E + 02 CR LF

The 3455A will output a measurement data message when addressed to "talk". The syntax for addressing the 3455A is dependent upon the controller being used. Refer to the Operating Manual of your controller for instructions.

NOTE

An overload measurement is indicated by an E + 10 exponent in the HP-IB measurement data. The large exponent is the key.

Also, note that the LF character (concurrent with EOI) is the last character in the data message and must be handshook from the 3455A to complete the measurement transfer.

3-69. Device Control Messages.

3-70. Device control messages are issued by the system controller to manage instruments on the bus. These messages are controller dependent. For specific information as to syntax and procedures to transmit the control messages, refer to the Operating Manual of the controller being used.

3-71. The following paragraphs describe the 3455A response to the various control messages.

3-72. Trigger Message. The trigger message causes the 3455A to initiate a measurement cycle. The 3455A must be addressed to "listen" in order to recognize the trigger message. The measurement results of the 3455A depend upon the control settings (FUNCTION, RANGE, etc.) at the time the trigger message is received.

3-73. Clear Message. Upon receiving the clear message, the 3455A sets the front panel controls to their "turn-on" state. The turn-on state is as follows:

FUNCTION	DC VOLTS
RANGE	AUTO
TRIGGER	INTERNAL
MATH	OFF
AUTO CAL	ON
HIGH RESOLUTION	OFF
DATA READY RQS	OFF
BINARY PROGRAM	OFF

The 3455A will respond to the device clear message whether addressed to "listen" or not. To respond to the selected device clear message, the 3455A must be addressed to listen.

3-74. Remote Message. The 3455A will go to Remote (Bus) control when the remote message, in conjunction with its "listen" address, is received. Remote operation is indicated when the REMOTE indicator, located above the display, is lit. During remote operation, the front panel controls cannot be operated manually.

3-75. Local Message. The local message returns the 3455A to LOCAL (manual) control. The 3455A can also be returned to local control by pressing the front panel LOCAL button. Some circuits of the instrument may also be in local operation when a local message is send to another instrument on the HP-IB.

7-76 Local Lockout Message. The local lockout message disables the front panel LOCAL control. In the local lockout mode, the 3455A cannot be returned to local operation from the front panel.

3-77. Clear Lockout and Local Message. The 3455A will set the front panel to LOCAL (manual) operation and enable the LOCAL control upon receiving the clear lockout and local message.

3-78. Interrupt and Device Status Messages.

3-79. The interrupt and device status messages permit the 3455A to notify the controller when an error in programming information or measurement output data occurs. The 3455A also uses these messages to notify the controller when measurement data is available if the DATA READY REQUEST feature is programmed.

3-80. Require Service Message. The following conditions will cause the 3455A to output a Require Service (SRQ) message.

a. *Data Ready.* If the DATA READY REQUEST feature is programmed, the 3455A will output an SRQ message upon completing the required measurement.

b. *Syntax Error.* The 3455A will output an SRQ message if a program code other than those listed in Table 3-4 is received. For example, the program code "F7" would cause a syntax error since the FUNCTION program set only contains codes F1 through F6.

c. *BINARY PROGRAM Error.* The 3455A will output an SRQ message if a BINARY PROGRAM code other than those listed in Table 3-5 is received.

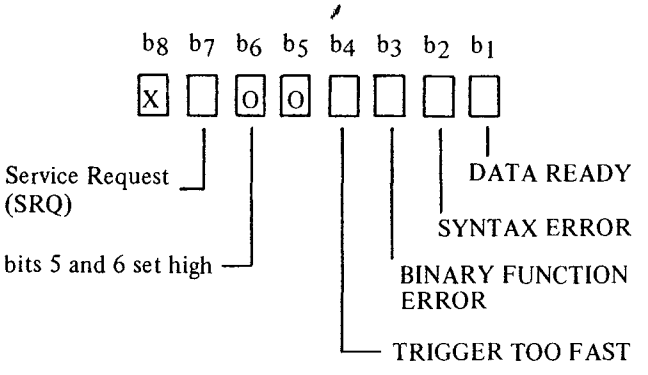
d. *Trigger Too Fast.* An SRQ message will be output if the 3455A is triggered while outputting data to the bus. This condition most commonly occurs if the 3455A is programmed to INTERNAL TRIGGER during bus operation. The front panel SRQ indicator is lit when the 3455A requires service. The Require Service message can be cleared by serial polling the 3455A or by clearing the 3455A.

3-81. Status Byte Message. The status byte message is output by the 3455A in response to a serial poll and indicates, to the controller, the nature of a service request message (SRQ) from the 3455A. The following is a list of the basic status byte codes output by the 3455A:

Status Byte Code		
ASCII CHAR	Decimal Code	
A	65	Data Ready - Indicates to the controller that measurement data is available. Applies to DATA READY Request feature.
B	66	Syntax Error - Indicates improper program code. Example - Program Code "F7" would cause a syntax error since the FUNCTION program set is only defined for codes F1 through F6.
D	68	BINARY FUNCTION Error - Indicates improper BINARY PROGRAM code or incomplete binary message. Similar to syntax error.
H	72	Trigger too Fast - Indicates the 3455A has been triggered while measurement data is being output to the bus. Warns of possible incorrect measurement information.

It is possible for more than one of the basic status byte messages to be true. In this case the resulting status byte code would be the combintation of the basic status byte codes being output. As an example, the resulting code for the combination of the syntax error and trigger too fast messages would be ASCII character J decimal code 74. The following illustrates the status Byte message indicating the purpose of each relevant "bit".

STATUS BYTE MESSAGE



NOTE

All "bits" are low true; bit 8 is not used.

3-82. DATA OUTPUT CHARACTERISTICS.

3-83. The protocol used by the 3455A to output measurement data must be followed in order to preserve proper data transfer over the HP-IB, the following notes on data transfer over the HP-IB may be helpful:

a. If a reading has been taken and thus resides in the output buffer, the buffer is not considered busy until the output handshaking begins. Thus, a new trigger will indicate a measurement and the new reading will replace the old reading. The old reading is lost and there is no SRQ condition.

b. Once the first character of measurement data has been handshaken out, the buffer is considered busy until one of the following occurs:

1. The balance of the reading is handshaken out.
2. "Device" or "Selected Device" clear is given.
3. The 3455A power is interrupted, triggering while the buffer is busy will lose the new reading and cause a "Trigger too Fast" SRQ condition.

c. When triggering and taking measurements in a loop, sufficient time must be allowed for the 3455A to perform the entire A-To-D measurement cycle and buffer data to become available after the first reading. The "Wait" statements in many 9800 series calculators are convenient methods to avoid outputting the previous buffer contents. This condition shows up as being "One reading behind" in your measurement sequence.

d. If you know the output buffer is not busy, but don't know whether it is full or not, sending a "device" or selected device" clear followed by reprogramming the desired conditions is a safe way to clear the output buffer.

3-84. Bail Out Message.

3-85. Abort. The Abort message unconditionally terminates all Bus communications and returns control to the system controller. Only the system controller can send the Abort message. Refer to the Operating Manual of the controller being used for instructions on sending the Abort Message.

3-86. Instrument Measurement Times (Remote Control).

3-87. In the Remote Operating mode, the 3455A takes a certain amount of time to respond to a trigger message. The overall time depends on the range, function, and particular controller used. This time may also vary from instrument to instrument. Table 3-6 gives the typical measurement times, using the HP-IB. These times are not part of the operating specifications of the instru-

ment, and are only provided as additional information for HP-IB system use. The following is an explanation of the various times involved in a measurement sequence.

a. *t1 (Typical Input Data Transfer Time):* This is the typical time it takes to transfer input data (set the 3455A to a certain function and range, etc) from a controller to the instrument. The transfer time depends on the number of ASCII character send to the instrument and the response time of the controller. For example, to send an "F1T3" message to the instrument takes four characters.

b. *t2 (Typical Input Settling Time):* The instrument is triggered (HP-IB, External, or Hold/Manual Trigger) and the 3455A begins to take a reading. This time consists of the settling time of the input relays, FETs, and other circuits.

c. *t3 (Typical Measurement Time):* The input measurement is taken at this time. This includes the A-to-D conversion time.

d. *t4 (Typical Computation Time):* When the measuring and the A/D operations are completed, the instrument's internal main controller circuits calculates the correct measurement reading. This time is the amount of the time it takes to complete the calculation.

d. *t5 (Typcial Output Data Transfer Time):* The 3455A now sends the reading to the HP-IB output buffers to be transferred to the controller. This time also depends on the response time of the particular controller.

3-88. Remote Programming Examples.

3-89. Appendix A at the end of this manual has Remote Programming examples for the 3455A. These examples are given in the HP Basic (-hp- Model 9830A/B Controller), HPL (-hp- Model 9825A Controller) and Enhanced Basic (-hp- Model 9835A/B and 9845A/B Controller) languages. The examples in the Appendix can be helpful when you write programs for the 3455A.

3-90. OPERATORS CHECKS.

3-91. The TEST feature provides a convenient method of testing the basic operational capabilities of the Model 3455A. This test plus an operational check of the Ohms and AC functions tests the major portion of the 3455A circuitry. Keep in mind the following checks test only the operating capability of the 3455A. They do not check the performance accuracy.

3-92. BENCH USE.

3-93. The following sequence may be used to manually check operational capability of the 3455A.

a. Set the 3455A to AUTO RANGE.

b. Press the TEST button. The display should be blank while the 3455A is performing the self test. Upon successful completion of the test, all front panel indicators (except the REAR TERMINAL indicator) will light and a reading of +8888888 with all decimals lit will be displayed. The self test will be repeated until another function is selected.

c. Connect a short across the INPUT terminals.

d. Press the 2 WIRE kΩ button. The front panel display should read .00000 ± 300 milliohms.

e. Press the ACV button. The display should read .00000 ± 600 microvolts.

3-94.HP-IB Operation.

3-95.Figure 3-5 shows the steps necessary to perform the 3455A operators check from the Bus.

Table 3-6. Typical HP-IB Controlled Measurement Times.

Function		Line Frequency	Input Data Transfer Time t1	Input Setting Time t2	Measurement Time t3	Computation Time t4	Output Data Transfer Time t5
DC Volts	High Resolution OFF Auto-Cal OFF	60 Hz	550 µsec per character plus the response time of Controller	12 msec	19 msec	12.5 ms for .1 V to 10 V Ranges	750 msec per character plus the response time of the controller (the 3455A output usage consists of 15 characters).
		50 Hz			22 msec		
	High Resolution ON Auto-Cal ON	60 Hz			14 msec	15.5 msec for 100 and 1000 V Ranges	
		50 Hz			22 msec		
	High Resolution ON Auto-Cal OFF	60 Hz			136 msec		
		50 Hz			162 msec		
	High Resolution ON Auto-Cal ON	60 Hz			136 msec		
		50 Hz			162 msec		
Ohms	High Resolution OFF Auto-Cal OFF	60 Hz		12 msec	48 msec		
		50 Hz		14 msec	55 msec		
	High Resolution OFF Auto-Cal ON	60 Hz		12 msec	48 msec		
		50 Hz		14 msec	55 msec		
	High Resolution ON Auto-Cal OFF	60 Hz		17 msec	280 msec		
		50 Hz		22 msec	330 msec		
	High Resolution ON Auto-Cal ON	60 Hz		17 msec	280 msec		
		50 Hz		22 msec	330 msec		
Normal AC Volts	Auto-Cal ON or OFF	60 Hz		35 msec	700 msec		
		50 Hz		42 msec	830 msec	12 msec all Ranges	
Fast AC Volts	Auto-Cal ON or OFF	60 Hz		12 msec	57 msec		
		50 Hz		14 msec	64 msec		

3455A Triggered at this time

Note: Time t3 should be used for each range being measured when the 3455A is in the Auto-range mode (see Paragraph 3-38.)

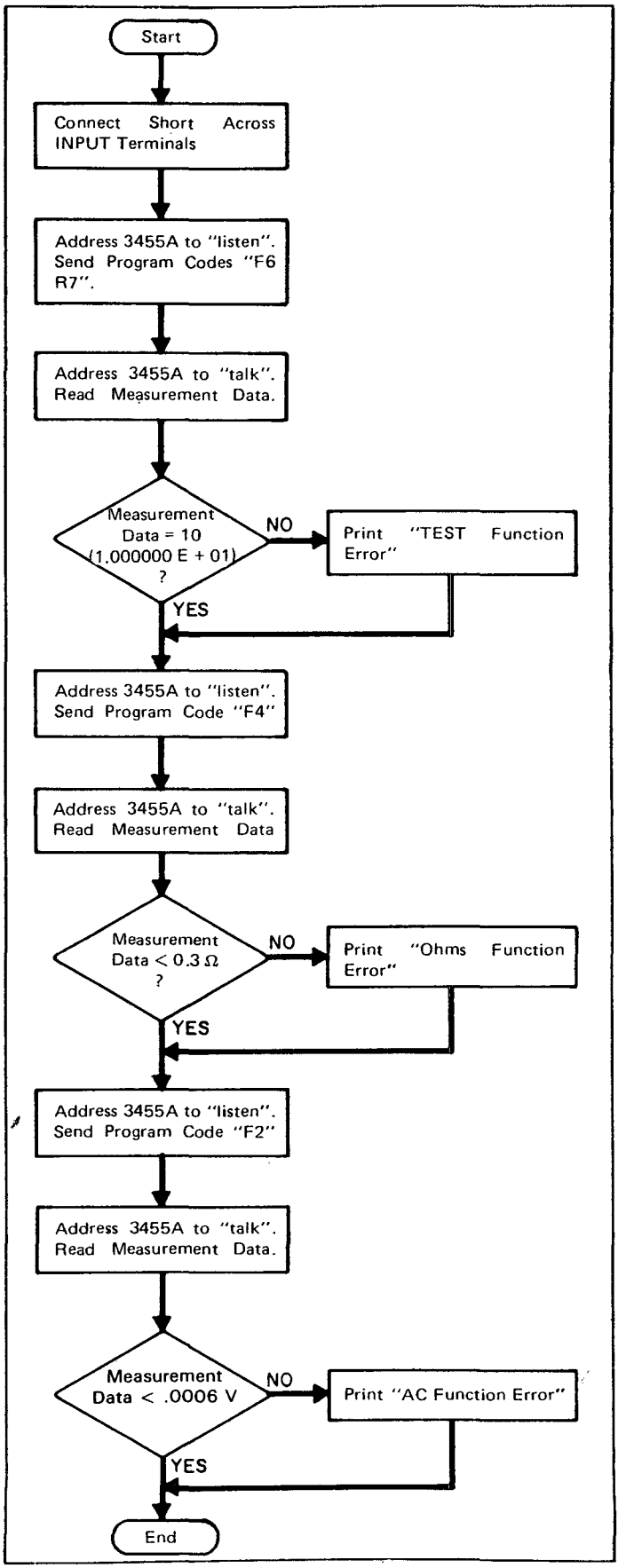


Figure 3-5. Operators Check Flowchart.

APPENDIX A

A-1. INTRODUCTION.

A-2. The following section of this manual gives some remote programming (HP-IB) examples for the 3455A. These examples are given in the HP Basic (-hp- Model 9830A/B Controller), HPL (-hp- Model 9825A Controller), and Enhanced Basic (-hp- Models 9835A/B and 9845A/B) Controller) languages.

A-3. For effective program writing, it is advisable to write a good algorithm first. Then write the 3455A program using the HP-IB information in Section III of this manual and the appropriate controller manual. Most -hp- controller manuals have a summary of the HP-IB messages (usually in the HP-IB section) in a tabular form. These messages are written in the respective controller languages and are given as sample HP-IB operations. This information and the following program examples can be very helpful when you start writing programs for the 3455A.

A-4. *Program Example #1:* In this program example, the 3455A is set up to take 50 readings quickly (with Auto-Cal off) and stores them into an Array. Each reading is printed out after all the readings have been taken. The 3455A is then set back to the Auto-Cal mode to insure accuracy. The programs in this example perform basically the same functions using different languages. The first program in this example is written in the HP Basic language, the second in HPL, and the third in Enhanced Basic.

Example # 1 (HP Basic).

```
10 DIM A[50]
20 CMD "?U6","F1R7T2T3A0D0"
30 FOR I=1 TO 50
40 CMD "?U6"
50 FORMAT 3B
60 OUTPUT (13,50)256,8,512
70 CMD "?V5"
80 FORMAT E13.6
90 ENTER (13,80)A[I]
100 NEXT I
110 CMD "?U6","A1"
120 FOR I=1 TO 50
130 PRINT A[I]
140 NEXT I
150 END
```

Set DVM to DCV (F1), Autorange (R7), Hold/Manual (T3), Auto-Cal Off (A0) and Data Ready Off (D0).
Begin For...Next Loop
Address DVM to Listen, Controller to Talk.
Format the Output.
Trigger the DVM (GET).
Set DVM to Talk.
Format the Output (reading).
Enter the Output into Variable.
Complete For...Next loop.
Auto-Cal on to Maintain Accuracy (A1).
Begin For...Next Loop.
Print the Entire Array.
Complete For...Next Loop
Ends the Program.

Example #1 (HPL).

```
0: dim A[50]
1: dev "Dvm",722
2: wrt "Dvm","F1R7T2T3A0D0"
3: for I=1 to 50
4: trg "Dvm"
5: red "Dvm",A[I]
6: next I
7: wrt "Dvm","A1"
8: fxd 6
9: for I=1 to 50
10: prt A[I]
11: next I
12: clr "Dvm"
13: spc 3
14: end
*27702
```

Dimension the Array.
Assign Name to the DVM Address.
Set DVM to DCV (F1), Autorange (R7), Hold/Manual (T3), Auto-Cal Off (A0), Data Ready Off (D0)
Begin For...Next Loop.
Trigger DVM (GET).
Enter the Reading into Variable.
Complete For...Next Loop.
Auto-Cal on to Maintain Accuracy.
Format the Output.
Begin For...Next Loop.
Print the Entire Array.
Complete For...Next Loop.
Clear the DVM (set to turn on state), (SDC).
Advance Printer 3 Spaces.
Ends the Program.

Example #1 (Enhanced Basic)

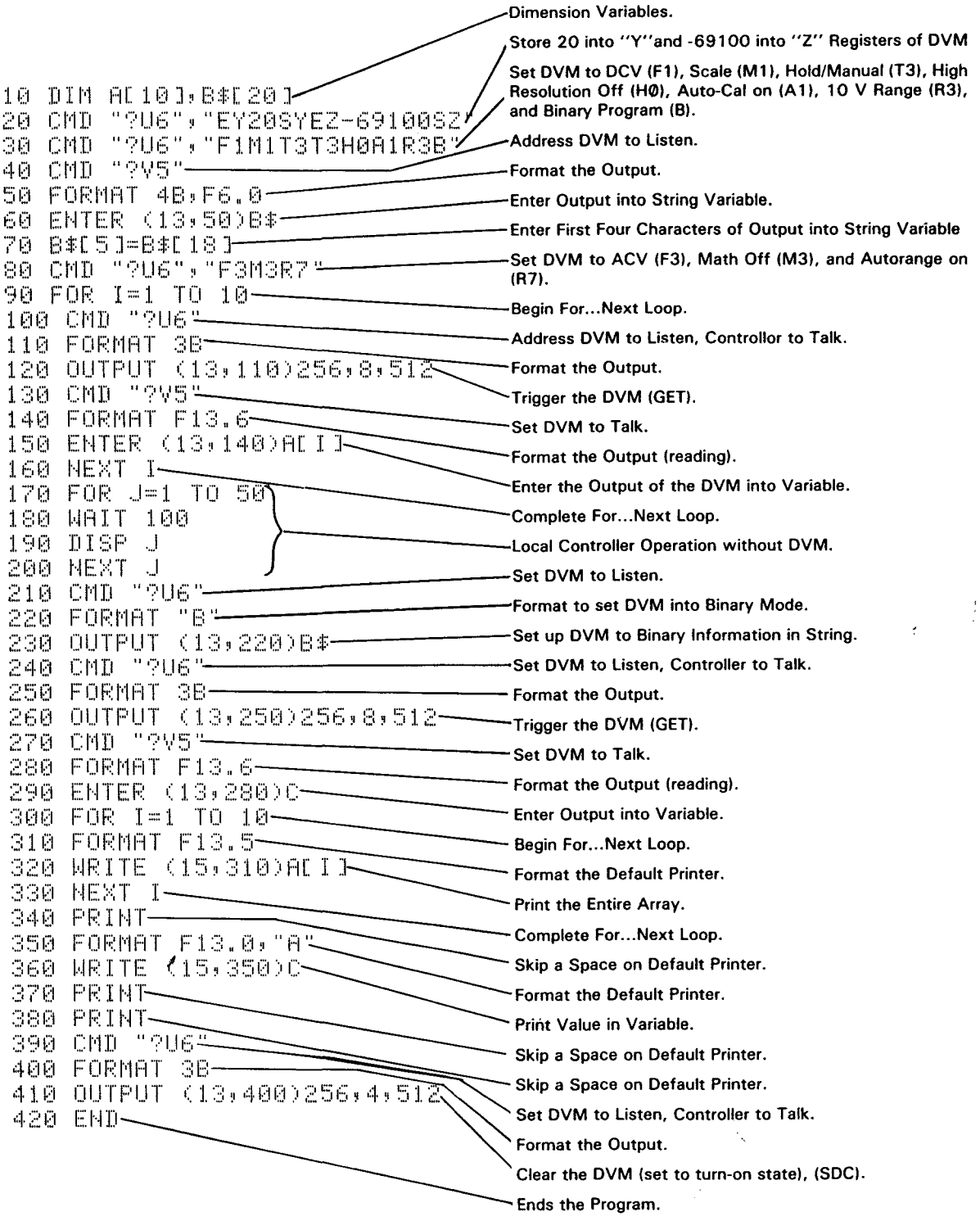
```
10   OPTION BASE 1
20   DIM Voltage(50)
30   Dvm=722
40   OUTPUT Dvm;"F1R7T2T3A0D0"
50   FOR Index=1 TO 50
60     TRIGGER Dvm
70     ENTER Dvm;Voltage(Index)
80   NEXT Index
90   OUTPUT Dvm;"A1"
100  FIXED 6
110  MAT PRINT Voltage
120  END
```

Choose Option Base for Array (see Note).
Dimension the Array.
Use Variable for DVM Address.
Set DVM to DCV CED, Autorange (R7), Hold/Manual (T3), Auto-Cal Off (A0), and Data Ready Off (D0
Begin For...Next Loop.
Trigger DVM (GET).
Enter the Reading into Variable.
Complete For...Next Loop.
Auto-Cal on to Maintain Accuracy.
Format the Array.
Print the Entire Array.
Ends the Program.

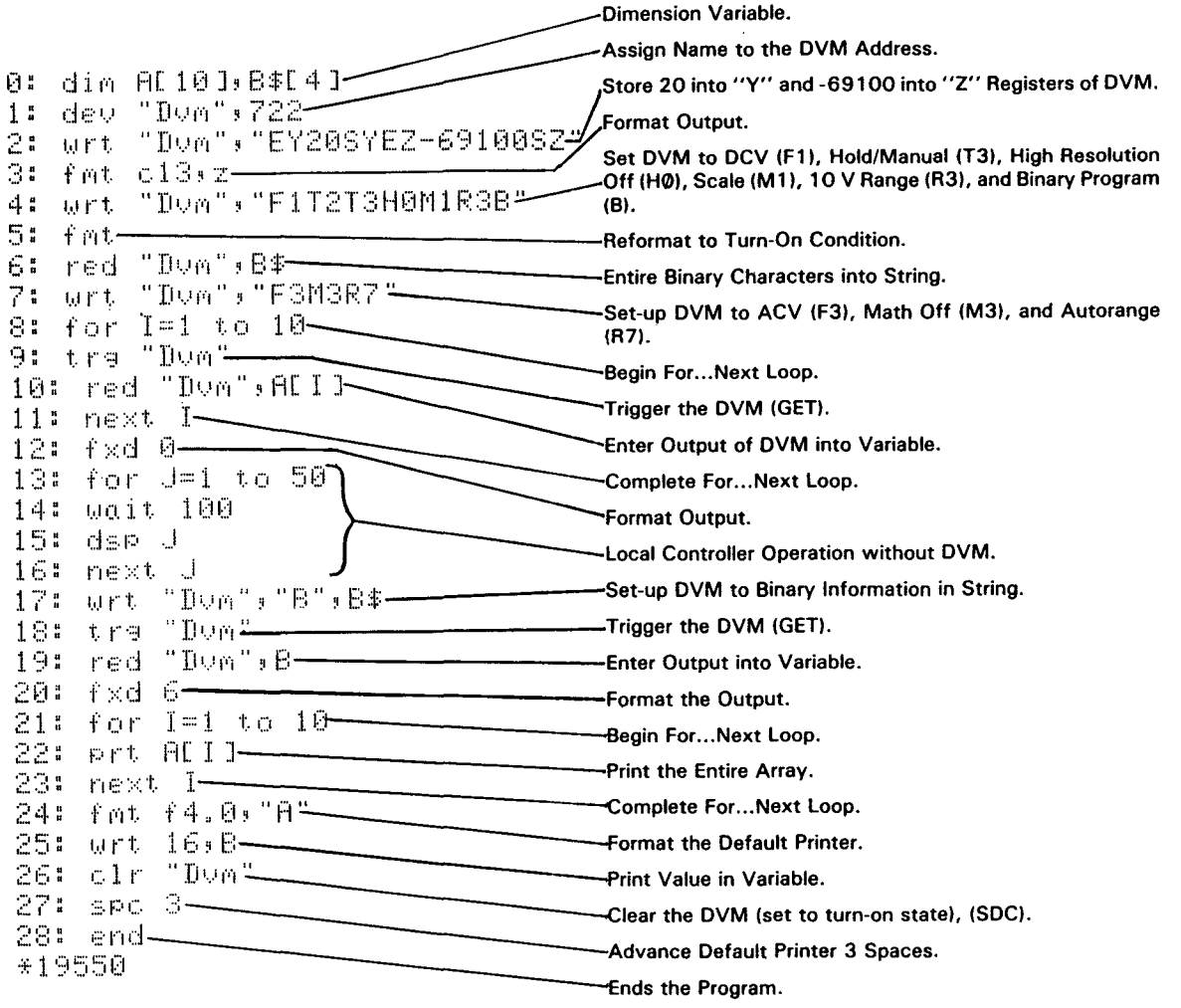
Note: Refer to Controller Manual for Explanation of Option Base

A-5. *Program Example #2:* When the 3455A is in the Binary mode, another feature called the "Learn Mode" can be used. With this feature, the set-up of the instrument (F1T3, etc) can be learned by the controller to be used later on in the program. This can be accomplished by sending the 3455A an ASCII "B" in the Data Mode and reading the next four bytes output by the instrument into a string variable. The instrument can then be reprogrammed to the previous set-up by using the string variable instead of program codes. It is important to remember to program the 3455A into the Binary mode by sending an ASCII "B". The instrument can transfer its set-up information to the controller in the Binary mode only. The following programs show how the "Learn Mode" feature can be used. These programs are written in the HP Basic, HPL, and Enhanced Basic languages.

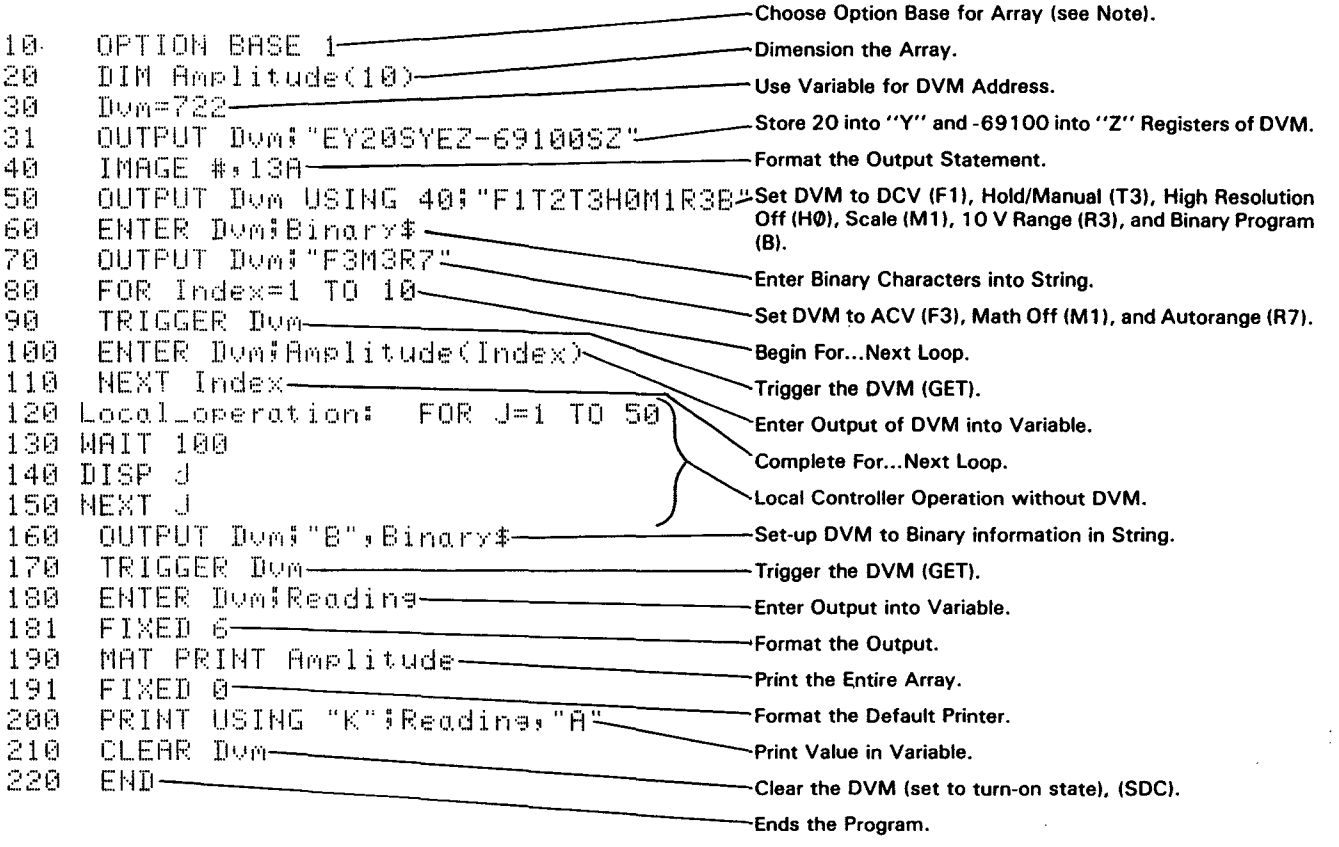
Example # 2 (HP Basic)



Example # 2 (HPL)



Example #2 (Enhanced Basic)



Note: Refer to Controller Manual for explanation of Option Base.