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. 03455-90011

Microfiche Part No. 03455-90061

P.O. Box 301, Loveland, Colorado, 80537 U.S.A.

Printed: July 1977

HEWLETT hp PACKARD

CERTIFICATION

Hewlett-Packard Company certifies that this instrument met its published specifications at the time of shipment from the factory. Hewlett-Packard Company further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY AND ASSISTANCE

This Hewlett-Packard product is warranted against defects in materials and workmanship for a period of one year from the date of shipment, except that in the case of certain components, if any, listed in Section I of this operating manual, the warranty shall be for the specified period. Hewlett-Packard will, at its option, repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard, and provided the proper preventive maintenance procedures as listed in this manual are followed. Repairs necessitated by misuse of the product are not covered by this warranty. NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. HEWLETT-PACKARD IS NOT LIABLE FOR CONSEQUENTIAL DAMAGES.

If this product is sold as part of a Hewlett-Packard integrated instrument system, the above warranty shall not be applicable, and this product shall be covered only by the system warranty.

Service contracts or customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

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 use 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.

(Specifications Apply with AUTO CAL On)

DC VOLTAGE

(High Resolution Off)

Accuracy: (1 digit = .001% of range)
- 24 hours; 23°C ± 1°C
  - 10 V range: ± (0.002% of reading + 1 digit)
  - 1 V range: ± (0.003% of reading + 1 digit)
  - 0.1 V range: ± (0.004% of reading + 4 digits)
  - 100 and 1000 V range: ± (0.004% of reading + 1 digit)
- 90 days, 23°C ± 5°C
  - 10 V range: ± (0.005% of reading + 1 digit)
  - 1 V range: ± (0.006% of reading + 1 digit)
  - 0.1 V range: ± (0.007% of reading + 4 digits)
  - 100 and 1000 V range: ± (0.007% of reading + 1 digit)
- 6 months; 23°C ± 5°C
  - 10 V range: ± (0.008% of reading + 1 digit)
  - 1 V range: ± (0.009% of reading + 1 digit)
  - 0.1 V range: ± (0.01% of reading + 5 digits)
  - 100 and 1000 V range: ± (0.010% of reading + 1 digit)

Temperature Coefficient: (0°C to 50°C)
- 0.1 V range: ± (0.0003% of reading + 0.15 digits)/°C
- 1 V range: ± (0.0003% of reading + 0.015 digits)/°C
- 10 V range: ± (0.00015% of reading + 0.01 digits)/°C
- 100 and 1000 V range: ± (0.0003% of reading + .01 digits)/°C

(High Resolution On)

Accuracy: (1 digit = .0001% of range)
- 24 hours; 23°C ± 1°C
  - 10 V range: ± (0.002% of reading + 3 digits)
  - 100 and 1000 V range: ± (0.004% of reading + 3 digits)
  - 1 V range: ± (0.003% of reading + 4 digits)
- 90 days; 23°C ± 5°C
  - 10 V range: ± (0.005% of reading + 3 digits)
  - 100 and 1000 V range: ± (0.007% of reading + 3 digits)
  - 1 V range: ± (0.006% of reading + 4 digits)
- 6 months; 23°C ± 5°C
  - 10 V range: ± (0.008% of reading + 3 digits)
  - 100 and 1000 V range: ± (0.010% of reading + 3 digits)
  - 1 V range: ± (0.009% of reading + 5 digits)

Temperature Coefficient: (0°C to 50°C)
- 1 V range: ± (0.0003% of reading + 0.15 digits)/°C
- 10 V range: ± (0.00015% of reading + 0.1 digits)/°C
- 100 and 1000 V range: ± (0.0003% of reading + 0.1 digits)/°C

Input Resistance:
- 0.1 V through 10 V range: > 10^{10} ohms
- 100 V and 1000 V range: 10 megohm ± 0.1%

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

Effective Common-Mode Noise Rejection (with 1 kΩ imbalance 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

Normal Mode Noise Rejection:
- 50 Hz Operation: > 60 dB at 50 Hz ± 0.1%
- 60 Hz Operation: > 60 dB at 60 Hz ± 0.1%

OHMS

(High Resolution Off)

Accuracy: 4 wire kilohms (1 digit = .001% of range)
- 24 hours; 23°C ± 1°C
  - 0.1 kΩ range: ± (0.003% of reading + 4 digits)
  - 1 kΩ range: ± (0.003% of reading + 1 digit)
  - 10 kΩ range: ± (0.005% of reading + 2 digits)
  - 100 kΩ range: ± (0.002% of reading + 2 digits)
  - 1000 kΩ range: ± (0.012% of reading + 5 digits)
  - 10,000 kΩ range: ± (0.1% of reading + 5 digits)
- 90 days; 23°C ± 5°C
  - 0.1 kΩ range: ± (0.005% of reading + 5 digits)
  - 1 kΩ range: ± (0.005% of reading + 1 digit)
  - 10 kΩ range: ± (0.007% of reading + 2 digits)
  - 100 kΩ range: ± (0.004% of reading + 2 digits)
  - 1000 kΩ range: ± (0.014% of reading + 5 digits)
  - 10,000 kΩ range: ± (0.100% of reading + 5 digits)
- 6 months; 23°C ± 5°C
  - 0.1 kΩ range: ± (0.005% of reading + 6 digits)
  - 1 kΩ range: ± (0.005% of reading + 1 digit)
  - 10 kΩ range: ± (0.007% of reading + 2 digits)
  - 100 kΩ range: ± (0.004% of reading + 3 digits)
  - 1000 kΩ range: ± (0.014% of reading + 5 digits)
  - 10,000 kΩ range: ± (0.100% of reading + 5 digits)

Temperature Coefficient: (0°C to 50°C)
- 0.1 kΩ range: (0.0003% of reading + 0.2 digits)/°C
- 1, 10 and 100 kΩ range: (0.0003% of reading + 0.02 digits)/°C
- 1000 kΩ range: (0.0005% of reading + 0.02 digits)/°C
- 10,000 kΩ range: (0.004% of reading + 0.02 digits)/°C

(High Resolution On)

Accuracy: 4 wire kilohms (1 digit = .0001% of range)
- 24 hours; 23°C ± 1°C
  - 1 kΩ range: ± (0.0025% of reading + 4 digits)
  - 10 kΩ range: ± (0.0045% of reading + 4 digits)
  - 100 kΩ range: ± (0.0020% of reading + 5 digits)
  - 1000 kΩ range: ± (0.0120% of reading + 4 digits)
  - 10,000 kΩ range: ± (0.1000% of reading + 4 digits)
- 90 days; 23°C ± 5°C
  - 1 kΩ range: ± (0.0035% of reading + 5 digits)
  - 10 kΩ range: ± (0.0060% of reading + 5 digits)
  - 100 kΩ range: ± (0.0035% of reading + 6 digits)
  - 1000 kΩ range: ± (0.0135% of reading + 5 digits)
  - 10,000 kΩ range: ± (0.1000% of reading + 5 digits)
- 6 months; 23°C ± 5°C
  - 1 kΩ range: ± (0.0040% of reading + 6 digits)
  - 10 kΩ range: ± (0.0065% of reading + 6 digits)
  - 100 kΩ range: ± (0.0040% of reading + 7 digits)
  - 1000 kΩ range: ± (0.0140% of reading + 6 digits)
  - 10,000 kΩ range: ± (0.1000% of reading + 6 digits)

Temperature Coefficient: (0°C to 50°C)
- 1, 10 and 100 kΩ range: ± (0.0003% of reading + 0.2 digits)/°C
- 1000 kΩ range: ± (0.0005% of reading + 0.2 digits)/°C
- 10,000 kΩ range: ± (0.004% of reading + 0.2% digits)/°C

Accuracy: 2 wire kilohms (High Resolution On or Off)
- All accuracy specifications are the same as 4 wire kilohms except add 0.0004 kΩ to all readings.

Maximum voltage generated across unknown:
- < 5 volts for open circuit
- < 4.7 volts for valid reading

Overload Protection:
- Non-Destructive — ± 350 V peak

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

AC VOLTAGE (RMS Converter)

Accuracy: (AC Coupling, input > 1% of full scale)
± (% of reading + digits)[1] (1 digit = .001% of range)

FAST ACV ACV	300 Hz–20 kHz 30 Hz–20 kHz	20 kHz–100 kHz 20 kHz–100 kHz	100 kHz–250 kHz[2] 100 kHz–250 kHz[2]	250 kHz–500 kHz[2] 250 kHz–500 kHz[2]	500 kHz–1 MHz[2] 500 kHz–1 MHz[2]
24 hours; 23°C ± 1°C	.04% + 40 dig.	0.4% + 80 dig.	1.8% + 200 dig.	4% + 400 dig.	5% + 1500 dig.
90 days; 23°C ± 5°C	.05% + 50 dig.	0.5% + 100 dig.	2.0% + 250 dig.	5% + 500 dig.	6% + 2000 dig.
6 months; 23°C ± 5°C	.06% + 60 dig.	0.6% + 130 dig.	2.1% + 300 dig.	5.1% + 600 dig.	6.3% + 2400 dig.

AC/DC coupled or AC coupled with input < 1% of full scale: Add + .05% of reading + 20 digits

[1] Guard must be connected to Low.
On the 1000 V range add 0.01 ppm/volt – kHz.

[2] Frequencies greater than 100 kHz specified on 1 and 10 V ranges only.

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

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

Input Impedance:
Front Terminals – 2 MΩ ± 1% shunted by less than 100 pF
Rear Terminals – 2 MΩ ± 1% shunted by less than 75 pF

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

AC VOLTAGE (Average Converter, Option 001)

Accuracy:
± (% of reading + digits)[1] (1 digits = .001% of range)

FAST ACV ACV	300 Hz–500 Hz 30 Hz–50 Hz	500 Hz–1 kHz 50 Hz–100 Hz	1 kHz–100 kHz 100 Hz–100 kHz	100 kHz–250 kHz[2] 100 kHz–250 kHz[2]
24 hours; 23°C ± 1°C	0.47% + 70 dig.	0.32% + 50 dig.	0.09% + 25 dig.	0.70% + 60 dig.
90 days; 23°C ± 5°C	0.50% + 70 dig.	0.35% + 50 dig.	0.1% + 25 dig.	0.75% + 60 dig.
6 month; 23°C ± 5°C	0.50% + 70 dig.	0.40% + 60 dig.	0.1% + 30 dig.	0.75% + 70 dig.

[1] Guard must be connected to Low
On the 1000 V range, add 0.01 ppm/volt–kHz.
Specifications are for input levels above 1/100th of range.

[2] Frequencies greater than 100 kHz specified on 1 and 10 V ranges only.

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

Input Impedance:
Front Terminals – 2 MΩ ± 1% shunted by less than 100 pF
Rear Terminals – 2 MΩ ± 1% shunted by less than 75 pF

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

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

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 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

Ranges: Maximum Display:

DC VOLTS

High Resolution Off	High Resolution On	High Resolution Off	High Resolution On
.1 V	———	± .149999 V	———
1 V	1 V	± 1.49999 V	± 1.499999 V
10 V	10 V	± 14.9999 V	± 14.99999 V
100 V	100 V	± 149.999 V	± 149.9999 V
1,000 V	1,000 V	± 1000.00 V	± 1000.000 V

Ranges: Maximum Display:

AC VOLTS

High Resolution On or Off	High Resolution On or Off
1 V	1.49999 V
10 V	14.9999 V
100 V	149.999 V
1,000 V	1000.00 V

OHMS

High Resolution Off	High Resolution On	High Resolution Off	High Resolution On
.1 kΩ	———	.149999 kΩ	———
1 kΩ	1 kΩ	1.49999 kΩ	1.499999 kΩ
10 kΩ	10 kΩ	14.9999 kΩ	14.99999 kΩ
100 kΩ	100 kΩ	149.999 kΩ	149.9999 kΩ
1,000 kΩ	1,000 kΩ	1499.99 kΩ	1499.999 kΩ
10,000 kΩ	10,000 kΩ	14999.9 kΩ	14999.99 kΩ

Maximum Reading Rate:

DC VOLTS

	60 Hz Gate Length		50 Hz Gate Length	
	High Resolution Off	High Resolution On	High Resolution Off	High Resolution On
Local	5 readings/sec	3 readings/sec	3.5 readings/sec	2.5 readings/sec
Remote	24 readings/sec	6 readings/sec	22 readings/sec	5 readings/sec

AC VOLTS

	60 Hz Gate Length		50 Hz 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

OHMS

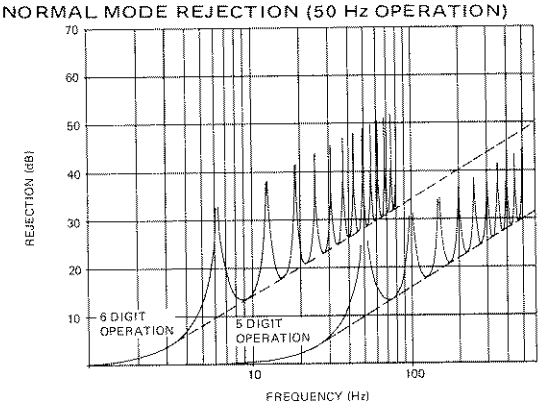
	60 Hz Gate Length		50 Hz Gate Length	
	High Resolution Off	High Resolution On	High Resolution Off	High Resolution On
Local	4.5 readings/sec	2 readings/sec	4 readings/sec	1.8 readings/sec
Remote	12 readings/sec	3 readings/sec	11 readings/sec	2.5 readings/sec

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

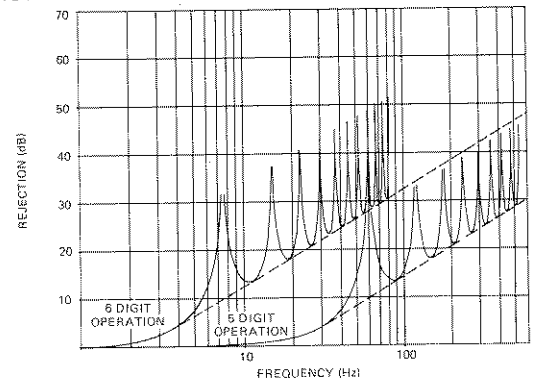
Response Time (RMS Converter)
ACV and FAST ACV
First reading to < 0.1% of step size when triggered coincident with step change when on correct range (no DC component)

Crest Factor (RMS) Converter):
7 to 1 at Full Scale

NORMAL MODE REJECTION (50 Hz OPERATION)



NORMAL MODE REJECTION (60 Hz OPERATION)

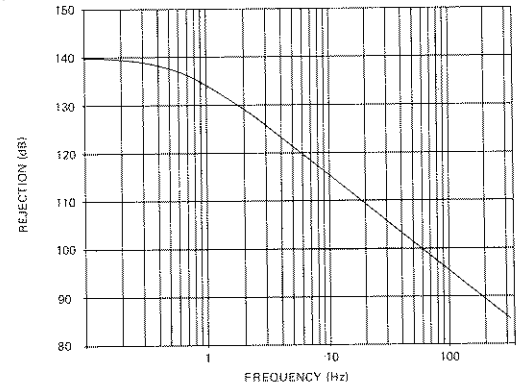


$$\text{Normal Mode Rejection} = 20 \log \left| \frac{\pi f T}{\sin \pi f T} \right|$$

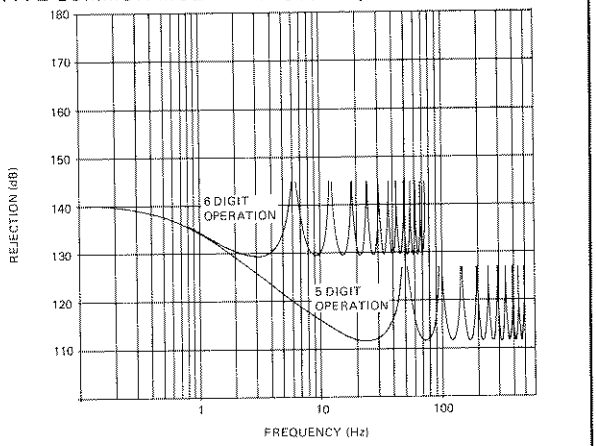
$$\text{Effective Noise Bandwidth} = \frac{1}{2T}$$

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

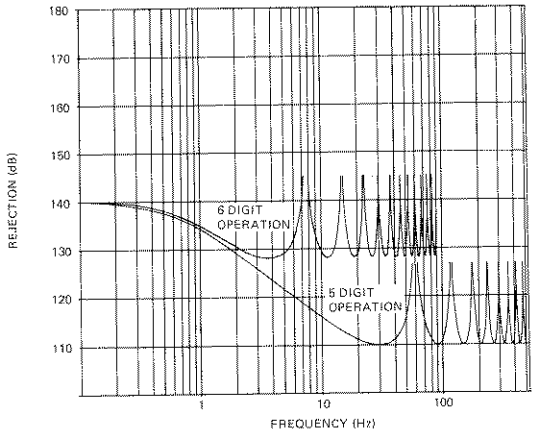
COMMON MODE REJECTION (1 KILOHM IMBALANCE)



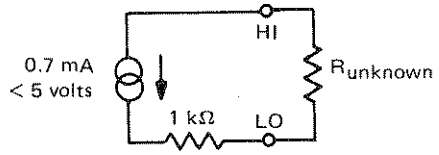
EFFECTIVE COMMON MODE REJECTION (50 Hz OPERATION)



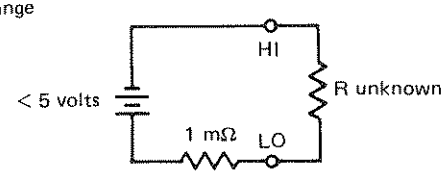
EFFECTIVE COMMON MODE REJECTION (60 Hz OPERATION)



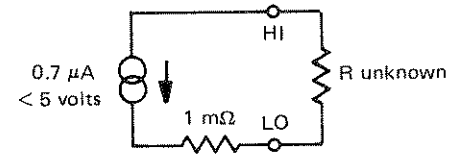
Equivalent Ohmmeter Circuits:
.1 kΩ, 1 kΩ, and 10 kΩ Ranges.



100 kΩ Range



1 M and 10 MΩ Ranges



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)

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

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.)

Table 1-3. Recommended Test Equipment.

Instrument	Critical Specification	Recommended Model	Use
DC Voltage Standard	Voltage: 10 mV to 1000 V Accuracy: ± .005%	-hp- Model 740B	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: 1 MΩ Accuracy: ± .002%	Guildine Model 9330/1 K or 9330A/1 K Guildline Model 9330/1 M	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 = Operational Verification Checks

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.

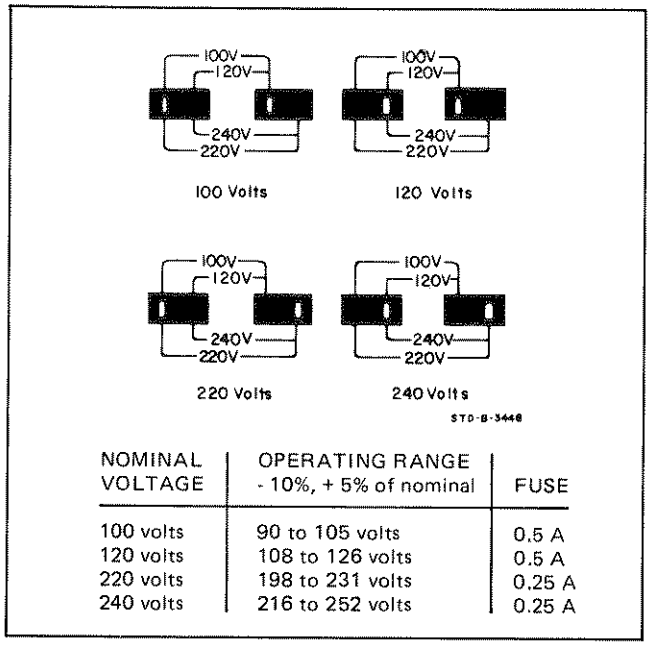
2-7. The Model 3455A requires a power source of 100, 120, 220, or 240 V ac (+ 5% - 10%), 48 Hz to 400 Hz single phase. Maximum power consumption is 60 VA.

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.

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.



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.

2-12. 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

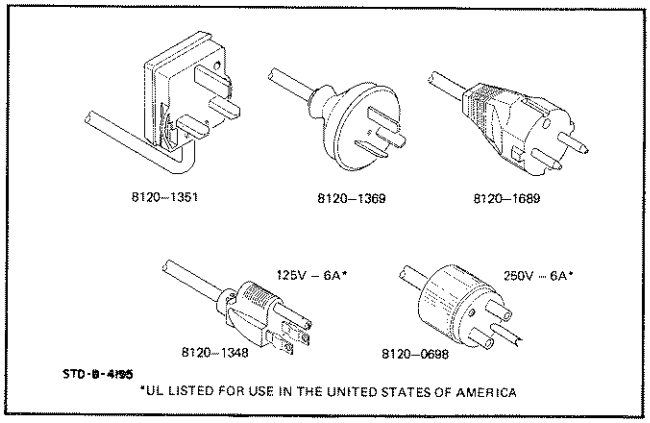


Figure 2-2. Power Cord Configurations.

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 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 interconnection 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.

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

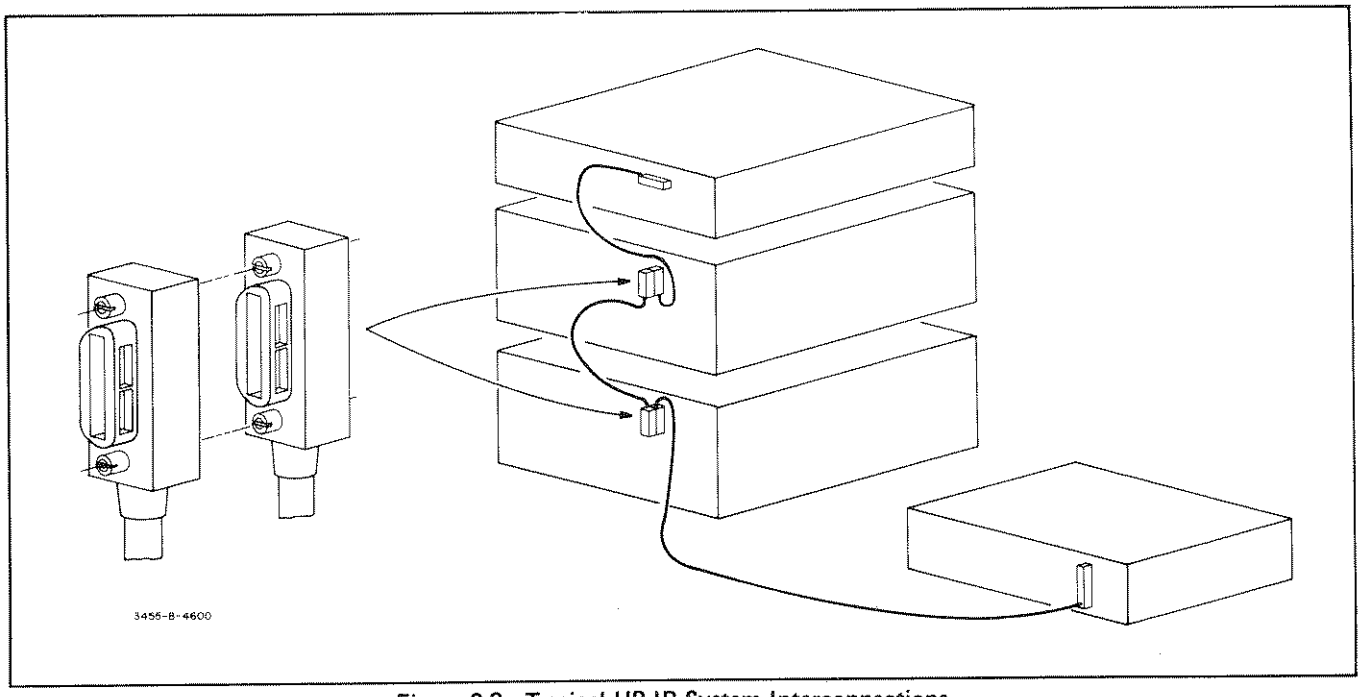


Figure 2-3. Typical HP-IB System Interconnections.

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.

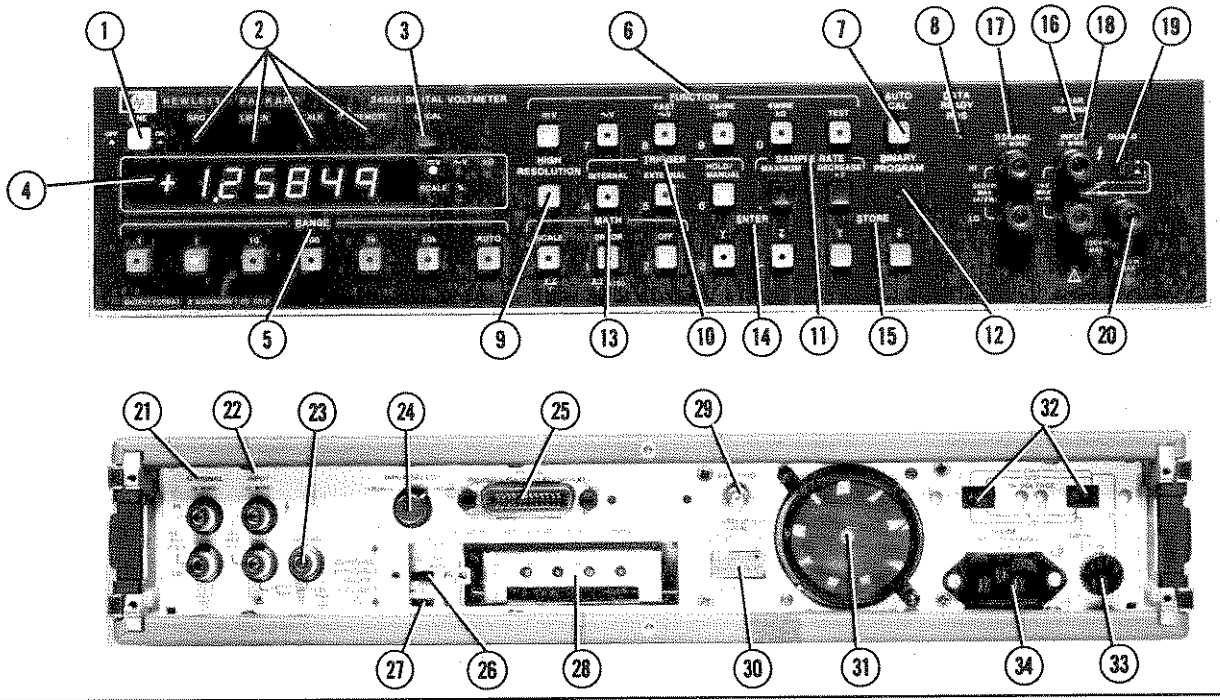
2-31. The following is a general guide for repackaging the instrument for shipment. If the original container is available, place the instrument in the container with appropriate packing material and seal well with strong tape or metal bands. If the original container is not available, proceed as follows:

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 3-67.
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 3-24.

(8) Data Ready Request Indicator — lights when the Data Ready Request feature is programmed on. Refer to Paragraph 3-54.

(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 3-55.

(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 3-14).

(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 3-18).

(15) STORE Controls — The Store controls transfer the number presently being displayed into the Y or Z register (Paragraph 3-18).

(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 operating 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 proper operation of most of the dc analog circuitry, inguard and outguard logic circuitry, and the front panel indicators and numeric display. The test routine is activated by the front panel TEST button. Successful completion of the test is indicated by all front panel indicators, except the REAR TERMINAL indicator, being lit and a numeric display reading of + 8888888 with all decimal points lit. The test routine will repeat until the test function is turned off. In the event of a test failure, the instrument is halted in the state in which the failure occurred and a numerical failure code is displayed to indicate which test failed. The Self-Test function can be remotely programmed as described in the programming portion of this section. The 3455A will output 1.000000 E + 01 upon successful completion of the test if addressed to "talk". The lack of this particular output indicates a test failure.

NOTE

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

3-8. DC Voltage Measurement.

3-9. The Model 3455A measures dc voltage from 1 microvolt to 1000 volts in five ranges extending from .1 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.

3-10. Resistance Measurement.

3-11. The Model 3455A measures resistance from 1 milliohm to 15 megohms in six ranges extending from .1 kil-

(17) Ohms Signal Terminals – supplies drive signal for 4-WIRE Ohms measurements (Paragraph 3-10).

(18) Input Terminals

(19) GUARD swtich – internally connects the Guard terminal to the LO Input terminal (for front panel operation only, Paragraph 3-30).

(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 Paragraphs 2-18 and 3-37.

(26) AC or AC/DC Input Selection switch – refer to Paragraph 3-12.

(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 3-42.

(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).

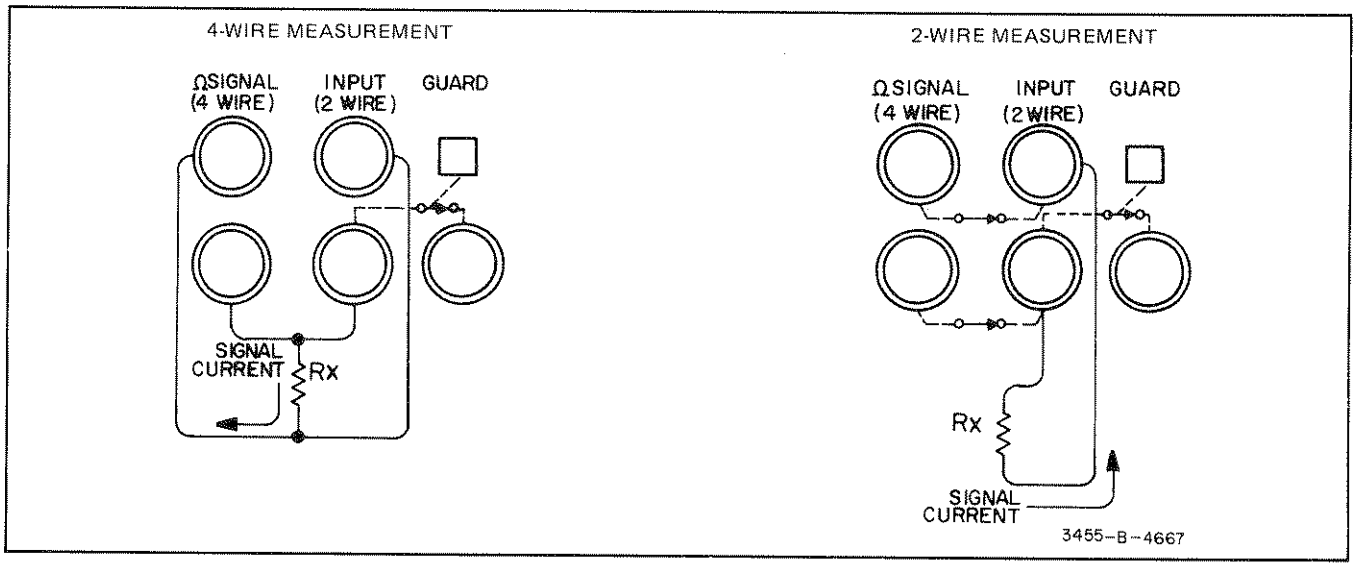


Figure 3-2. Ohmmeter Measurement Connections.

ohms full 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. 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.

3-12. AC Voltage Measurement.

3-13. The Model 3455A offers a choice of a true rms ac converter (standard unit) or an average responding ac converter (Option 001). Both methods measure ac volts from 10 microvolts to 1000 volts in four ranges extending from 1 volt full-scale to 1000 volts full-scale. All ranges except the 1000 volt range have 50% overrange capability and are protected from input voltages up to 1000 volts rms. Measurement results are presented in 5-1/2 digits only for ac measurements. In addition to the AC Volts Function, the 3455A has a FAST AC Volts Function which allows ac measurements to be made more rapidly. However, bandwidth is reduced when using the ac fast function. Input impedance of both converters is 2 megohms in parallel with < 65 pF for rear terminal input or < 90 pF for front terminal input. The average responding converter has a frequency range of 30 Hz to 250 kHz in the AC Volts function and 300 Hz to 250 kHz in FAST AC Volts. Frequency response of the true rms converter is from 30 Hz to 1 MHz in the AC Volts Function and 300 Hz to 1 MHz in the FAST AC Volts Function. The true rms converter allows measurement of ac or ac plus dc signals (ac signals superimposed on a dc level). Selection of ac or ac + dc is selected by a switch located behind the rear panel reference cover. The average responding converter measures ac signals only. Refer to Table 1-1 for accuracy specifications for each converter.

3-14. Math Feature.

3-15. The math feature of the 3455A allows the measurement value to be offset and/or scaled by known values or to be expressed in percent of a reference value.

3-16. 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 perfomed by entering $\emptyset$ in "z" and the divisor value in "y". The scale formula then becomes: result = $\frac{x - \emptyset}{y} = \frac{x}{y}$. 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 = $\frac{x - \emptyset}{1/y} = xy$. As an example: to multiply by 10, divide by the inverse of 10 which is 1/10 or .1. An example application of the scale mode would be to use the 3455A to measure temperature using a linear resistive temperature sensor. Assume that the sensor has a resistance of 1 kilohm at 25°C and changes 5900 ppm/°C. At $\emptyset$°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 equa-

tion are equal to 25°C since the sensor resistance is specified at that temperature. The scale equation becomes:

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

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

3-17. % Error Mode. The % error mode of the math feature is described by the formula: result in $\% = \frac{x - y}{y} \times 100$, 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. The 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: % error $= \frac{.790 - 750}{750} \times 100 =$ 5.33333%, indicating the resistor is out of tolerance by .33333%.

3-18. Enter and Store.

3-19. 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.

3-20. The STORE keys are used to transfer the number presently being displayed to the "Y" or "Z" memory registers and to return the voltmeter to normal operation.

3-21. 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.

3-22. High Resolution Mode.

3-23. The HIGH RESOLUTION mode increases the measurement integration period by a factor of eight allowing a measurement presentation of 6-1/2 digits. This changes the measurement resolution from 10 parts/1.5 million (normal 5-1/2 digit presentation) to 1 part/1.5 million. The High Resolution mode applies to dc volts and ohms functions only.

3-24. Auto-Cal.

3-25. The purpose of the AUTO-CAL feature is to eliminate offset and gain errors which may be present in the analog circuitry of the 3455A. This is accomplished by measuring the offset and gain errors and mathematically correcting the measurement reading to exclude them. Each error measurement is stored in "memory" by the 3455A main controller as an Auto-Cal constant. These constants are sequentially updated between measurement readings. The Auto-Cal feature may be switched off to allow faster measurement reading rates. When the Auto-Cal feature is switched off the last set of constants taken are used to correct the measurement readings, thereby maintaining short term accuracy.

3-26. Trigger.

3-27. The 3455A has three TRIGGER modes, INTERNAL, EXTERNAL, and HOLD/MANUAL mode. The measurement trigger is initiated each time the HOLD/MANUAL button is pressed. In the INTERNAL TRIGGER mode, the measurement trigger is generated internally. The trigger rate is dependent upon the function selected and whether the AUTO-CAL and HIGH RESOLUTION features are being used. The EXTERNAL TRIGGER mode allows the measurement trigger to be initiated by an external source. The external trigger requires a negative going TTL compatible signal to initiate the measurement trigger. The external trigger signal is applied through a BNC connector located on the rear panel.

3-28. Sample Rate.

3-29. The maximum sample rate of the 3455A is dependent upon the function selected, the power line frequency, and whether the instrument is in the AUTO-CAL and/or HIGH RESOLUTION operating modes. Table 3-1 lists the maximum sample rates for the various functions and modes

of operation. The sample rate may be decreased by pressing the DECREASE ÷ 2 button. Each time this button is pressed, the current sample rate is divided by two. The sample rate may be divided a maximum of six times for a sample rate of 1/64 maximum sample rate.

3-30. GUARDING.

3-31. Common-Mode Voltages.

3-32. 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.

3-33. Guard Connection.

3-34. 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.

Table 3-1. Maximum Sample 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) 4 readings/sec (50 Hz)
	ON	OFF	6 readings/sec (60 Hz) 5 readings/sec (50 Hz)
	OFF	OFF	25 readings/sec (60 Hz) 20 readings/sec (50 Hz)
Ohms	ON	ON	1.5 readings/sec (60 Hz) 1 reading/sec (50 Hz)
	OFF	ON	2.5 readings/sec (60 Hz) 2 readings/sec (50 Hz)
	ON	OFF	3 readings/sec (60 Hz) 2.5 readings/sec (50 Hz)
	OFF	OFF	12 readings/sec (60 Hz) 10 readings/sec (50 Hz)
AC Volts	Not Applicable	ON	1.5 readings/sec (60 Hz) 1.3 readings/sec (50 Hz)
	Not Applicable	OFF OFF	1.5 readings/sec (60 Hz) 1.3 readings/sec (50 Hz)
Fast AC Volts	Not Applicable	ON	5 readings/sec (60 Hz) 4 readings/sec (50 Hz)
	Not Applicable	OFF OFF	16 readings/sec (60 Hz) 12 readings/sec (50 Hz)

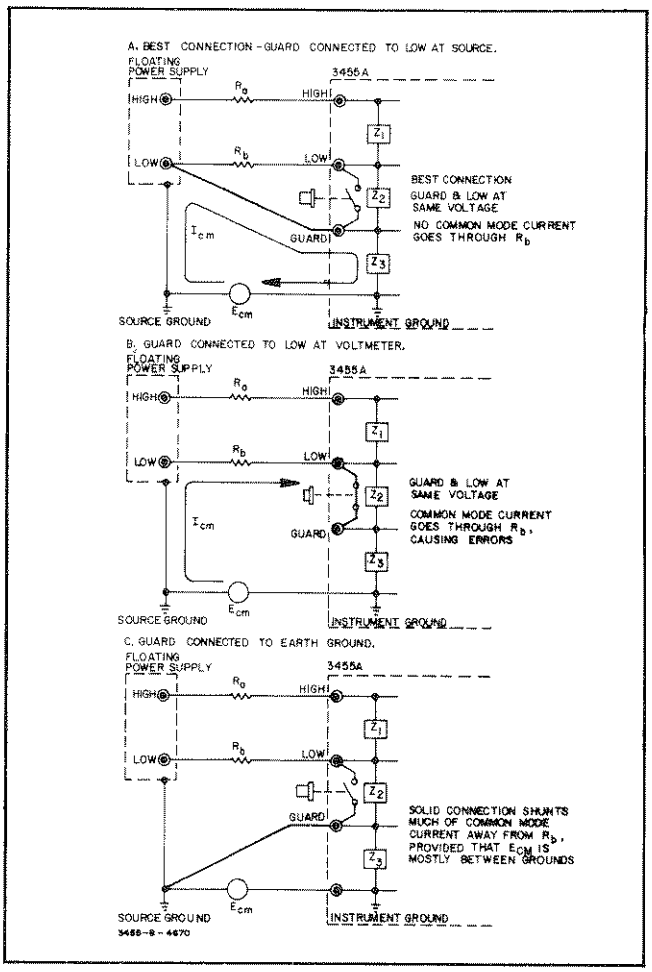


Figure 3-3. Connecting the Guard.

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.

3-35. Guarding Information.

3-36. 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.

3-37. REMOTE OPERATION.

3-38. General.

3-39. 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."

3-40. 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.

3-41. 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.

3-42. Address Selection.

3-43. 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).

3-44. 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 data each time a measurement sample is made. Selection of FUNCTION, RANGE, TRIGGER, etc. is accomplished manually using the front panel controls.

NOTE

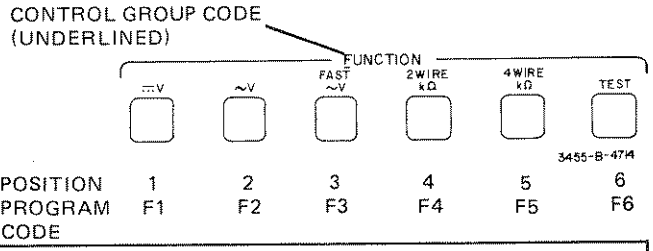
When the 3455A is connected to a system with a controller, the TALK ONLY switch must be set to the off position.

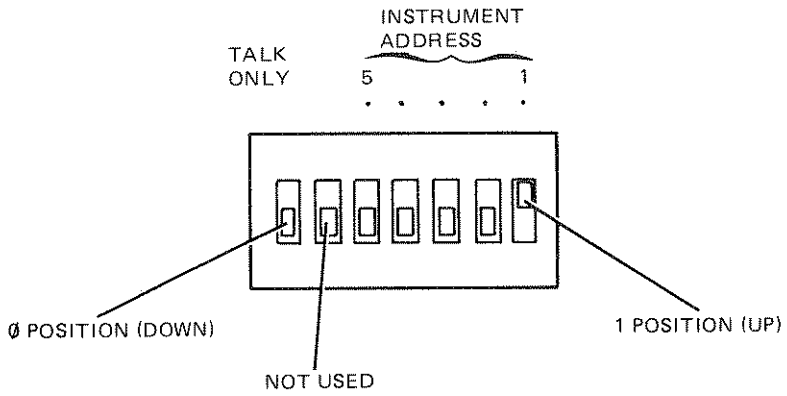
Table 3-3. Bus Messages.

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.

3-45. Program Codes.

3-46. 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 Decimal Code
Listen	Talk	A5	A4	A3	A2	A1	
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
Ø	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

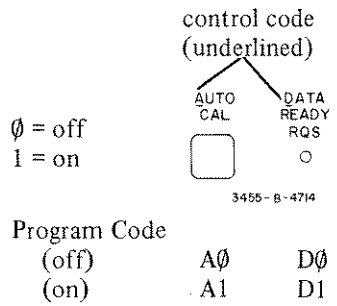
Figure 3-4. Address Selection.

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

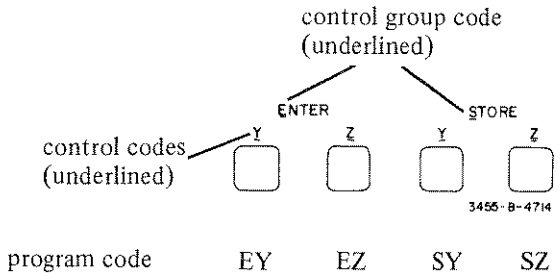
3-47. The program code for single control features which can only be programmed on or off (AUTO CAL and HIGH RESOLUTION) consist of the letter underlined in the control heading and the number "Ø" for off or the number "1" for on. This also applies to the DATA READY Request feature which is Bus programmable only.

Example:



3-48. 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:



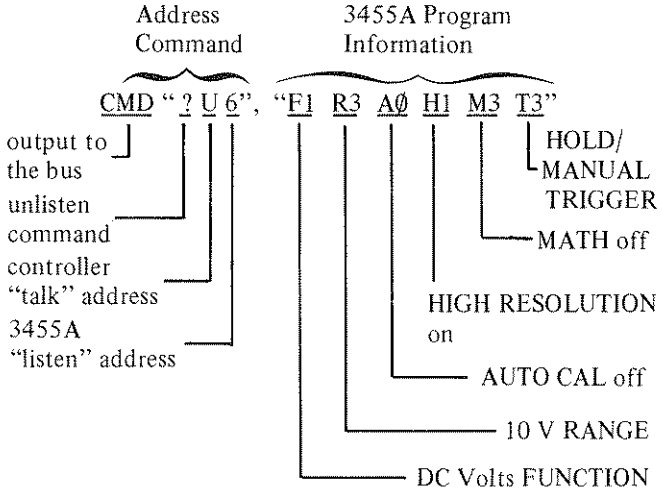
3-49. The program code for the BINARY PROGRAM feature consists of only the underlined character in the control heading (B).

3-50. Data Messages.

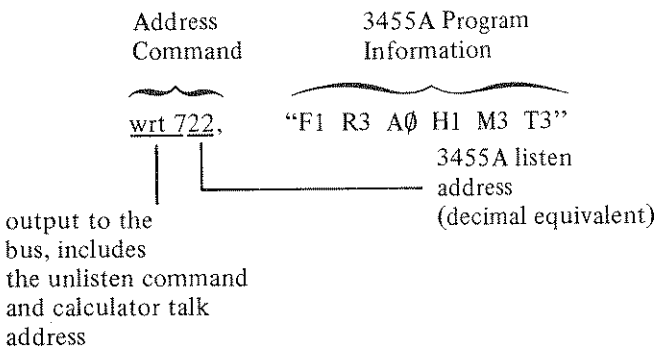
3-51. The major portion of communications transmitted over the Bus is accomplished by data messages. Data messages are used by the controller to program the Model 3455A and are used by the 3455A to transmit measurement data. These functions are explained in the following paragraphs.

3-52. 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:

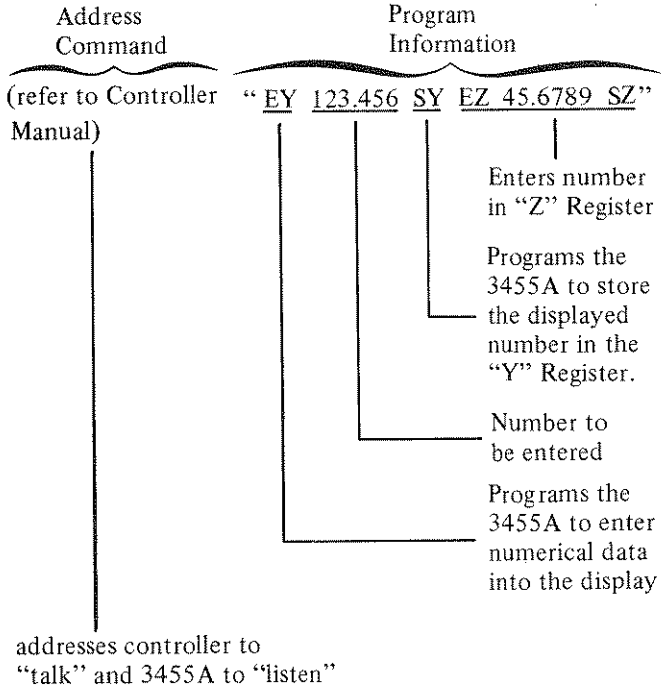


Program data message using the 9830A Calculator.

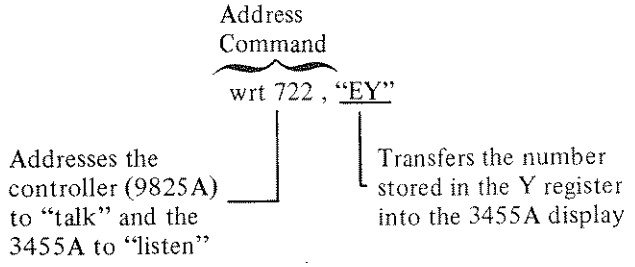


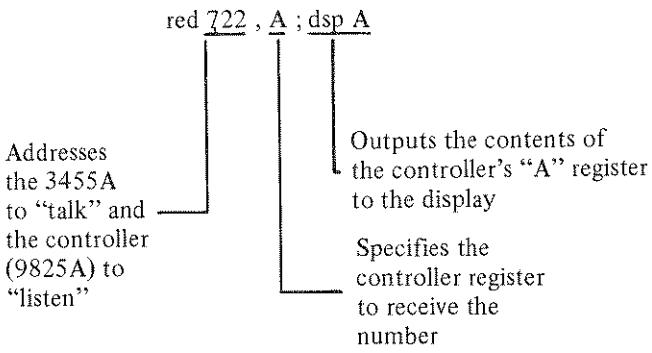
Program data message using the 9825A Calculator.

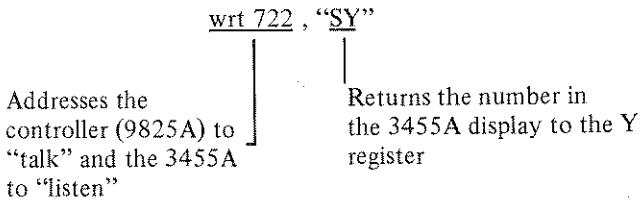
3-53. Entering MATH Constants (Y and Z) from the Bus. The following data message illustrates the program information necessary to enter numbers into the Y and Z registers:



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:





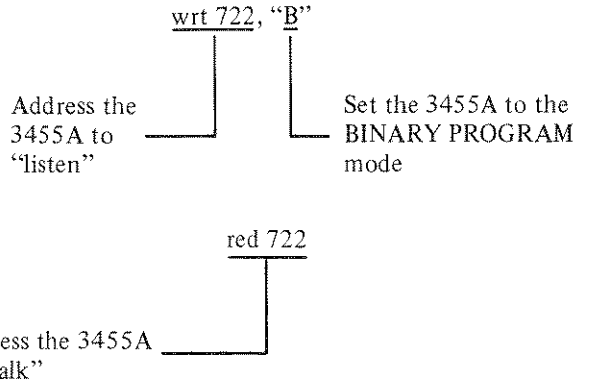


3-54. Data Ready Request. The DATA READY Request feature permits the 3455A to signal the controller upon the completion of a measurement. This feature would normally be used where the 3455A is triggered from an external source. In this mode of operation, the 3455A is programmed to the appropriate measurement 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 is ready. Upon receiving the service request, the controller will 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:

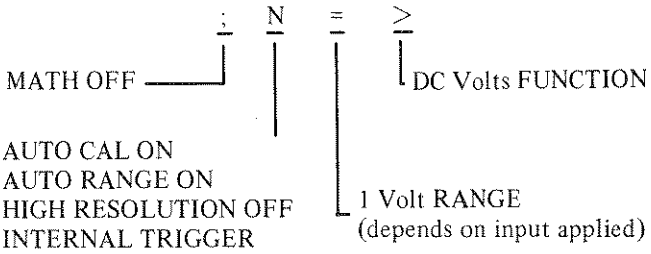
DØ Data Ready Request off
D1 Data Ready Request on

3-55. 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. Table 3-5 lists the allowable BINARY PROGRAM codes for each of the four data bytes and the front panel keys they control.

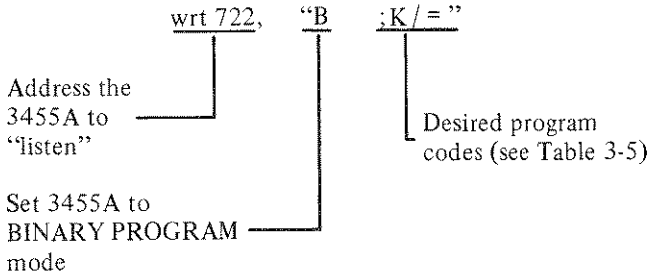
3-56. The following data message examples illustrate how to read or program the front panel control status of the 3455A. To read control status:



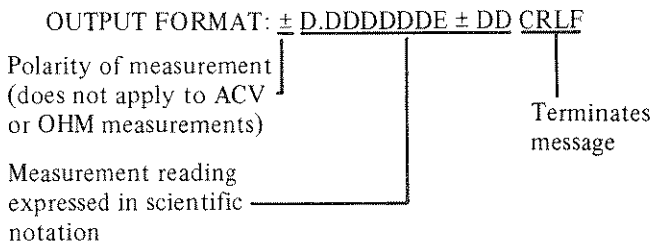
The 3455A, after receiving the "talk" command, will output the front panel control status codes (4 bytes). As an example, if the front panel controls were in the "turn-on" state, the 3455A would output the following codes:



To program front panel controls:



3-57. Measurement Data. Measurement data is output by the 3455A in the following general format:



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

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

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.

3-58. Device Control Messages.

3-59. 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.

3-60. The following paragraphs describe the 3455A response to the various control messages.

3-61. 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.

3-62. 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.

3-63. 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.

3-64. 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.

3-65. 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.

3-66. 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.

3-67. Interrupt and Device Status Messages.

3-68. 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.

3-69. 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.

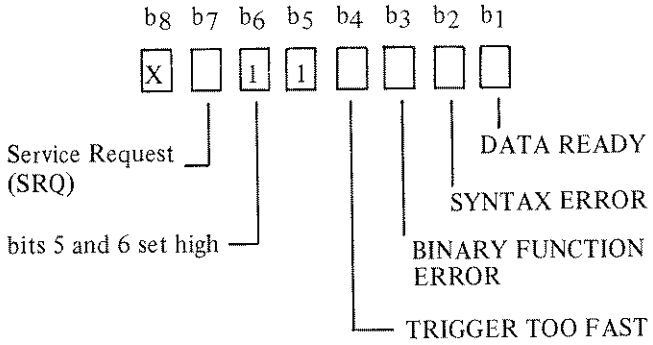
The front panel SRQ indicator is lit when the 3455A requires service. The Require Service message can be cleared by re-addressing the 3455A to "listen" or by serial polling the 3455A.

3-70. 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 combination 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.

3-71. Bail Out Message.

3-72. 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.

3-73. OPERATIONAL VERIFICATION CHECKS.

3-74. 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.

3-75. Bench Use.

3-76. 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 ± 300 microvolts.

3-77. HP-IB Operation.

3-78. Figure 3-5 shows the steps necessary to perform the 3455A verification check from the Bus.

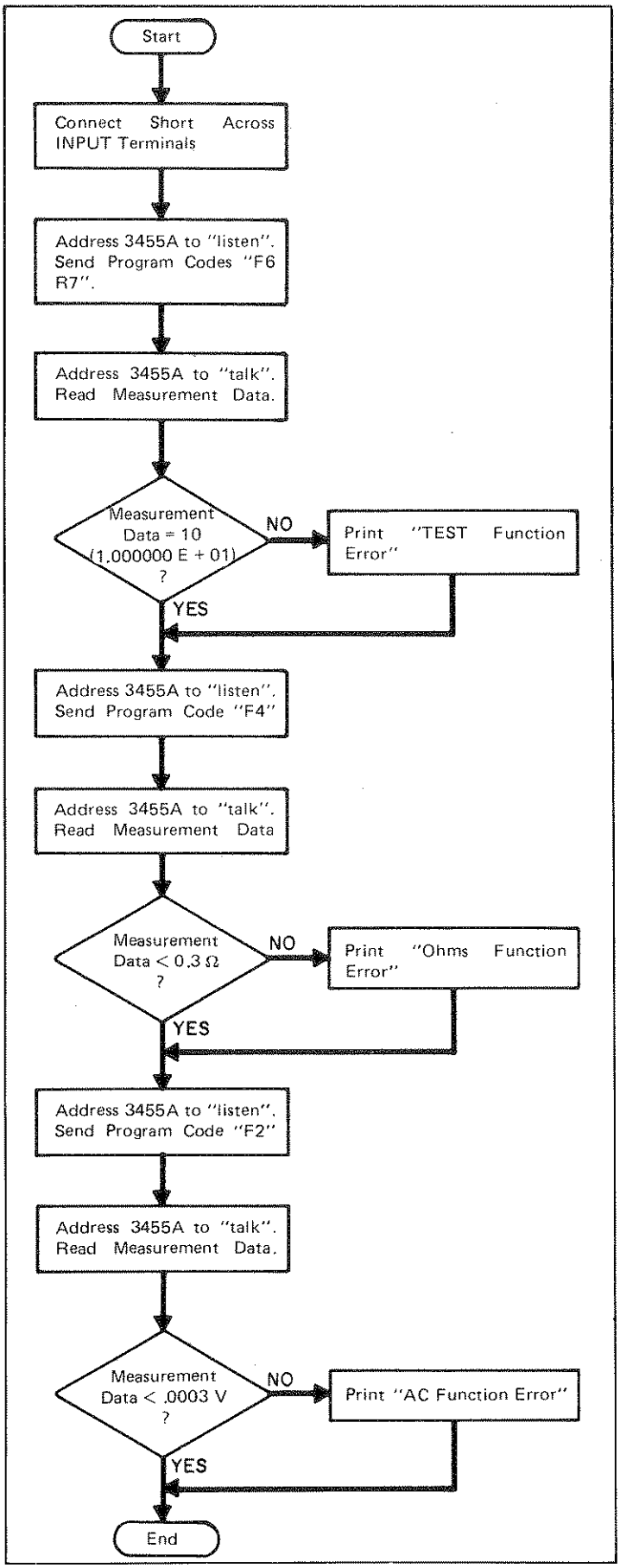


Figure 3-5. Operational Verification Flowchart.

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