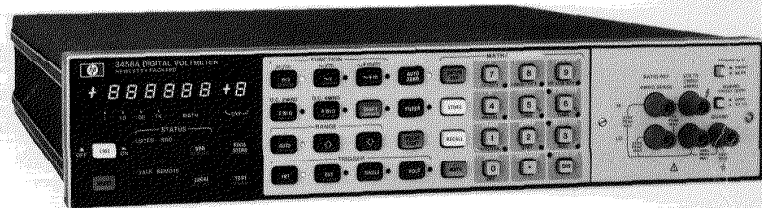


OPERATING MANUAL

DIGITAL VOLTMETER 3456A



 **HEWLETT
PACKARD**



OPERATING MANUAL

MODEL 3456A

DIGITAL VOLTMETER

SERIAL NUMBERS

This manual applies directly to instruments with a serial number prefix of 2201.

Instruments with a prefix of 2015, and serial numbers 2015A04595 and below, refer to Section VII (Manual Changes) of this manual. For information on instruments with a prefix other than listed in Section VII and on the title page, refer to the manual change sheet.

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. 03456-90006

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

Printed: March 1982



CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard 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

This Hewlett-Packard product is warranted against defects in material and workmanship for a period of one year from date of shipment [except that in the case of certain components listed in Section I of this manual, the warranty shall be for the specified period] . During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by -hp-. Buyer shall prepay shipping charges to -hp- and -hp- shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to -hp- from another country.

Hewlett-Packard warrants that its software and firmware designated by -hp- for use with an instrument will execute its programming instructions when properly installed on that instrument. Hewlett-Packard does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HEWLETT-PACKARD SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

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ASSISTANCE

Product maintenance agreements and other 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.

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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.

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.

A

v

SAFETY SYMBOLS

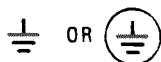
General Definitions of Safety Symbols Used On Equipment or In Manuals.



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.



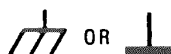
Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).



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).

WARNING

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.

CAUTION

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. The information contained in this Manual is for the Installation, Operation, HP-IB Programming and Service of the Hewlett-Packard Model 3456A Digital Voltmeter.

NOTE

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

1-3. The Installation, Operating, and HP-IB Programming information in this Manual is also contained in the Operating Manual.

1-4. This section in the Manual contains general information concerning the 3456A Digital Voltmeter. Included are instrument description, specifications, supplemental characteristics, instrument and manual identification, options, accessories, and other information on the instrument.

1-5. DESCRIPTION.

1-6. The Hewlett-Packard Model 3456A is a versatile Digital Voltmeter with ac, dc, ohms, and various math functions. This voltmeter is an excellent bench meter and since it is remotely programmable it is an exceptional system measurement device. Other features for which you may have some good uses are the selection of power line cycles integrated, the selection of certain number of readings/trigger, settling delay, ratio, and other unique and useful functions.

1-7. The 3456A also employs a feature called AUTO ZERO. This feature of the instrument is very useful for good stability. The internal reference device and reference resistors are also selected for good accuracy and stability. Another good feature is the TEST function of the 3456A. With this function the instrument's operation can be partially verified for correct operation by the operator.

1-8. SPECIFICATIONS.

1-9. Specifications of the 3456A are the performance

characteristics of the instrument which are warranted. These specifications are listed in Table 1-1, and are the performance standards or limits against which the instrument can be tested. Included in Table 1-1 are also some supplemental characteristics of the 3456A and should be considered as additional and general information for you, the user. Because of the many operational capabilities of the 3456A, exercise care when determining the instrument's specifications.

1-10. Any changes in the specifications due to manufacturing changes, design, or traceability to the National Bureau of Standards will be covered in a manual change supplement or revised manual pages. The specifications listed here supercede any previously published.

1-11. INSTRUMENT AND MANUAL IDENTIFICATION.

1-12. Instrument identification is by a serial number located on the rear panel of the instrument. Hewlett-Packard uses a two-part serial number. The first part (prefix) identifies a series of instruments and the last part (suffix) identifies a particular instrument within a series. A letter between the prefix and suffix identifies the country in which the 3456A is manufactured.

1-13. This Manual applies to instruments with serial number indicated on the title page. Updating of the manual is accomplished either by a change sheet or revised pages.

1-14. OPTIONS.

1-15. The following options are available for use with the 3456A:

- Option 350: for 50 Hz Power Source
- Option 360: for 60 Hz Power Source
- Option 907: Front Handle Kit
- Option 908: Rack Mounting Kit
- Option 909: Front Handle and Rack Mounting Kit
- Option 910: Additional Set of Manuals

1-16. ACCESSORIES SUPPLIED.

1-17. The 3456A is supplied with a 3/8 amp, 250V fuse for the 220V and 240V power line voltages.

1-18. ACCESSORIES AVAILABLE.

1-19. The following is a list of available accessories for the 3456A:

Accessory No.	Description
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.)
10631D	HP-IB Cable 0.5 Meter (19.69 in.)
11000A	Test Leads, Dual Banana Both Ends
11002A	Test Leads, Dual Banana to Probe and Alligator
34111A	High Voltage Probe (40 kV dc)
44414A	4 Thermistors

1-20. SAFETY CONSIDERATION.

1-21. The 3456A is a safety class 1 instrument (provided with a protective earth connection). The instrument and manual should be reviewed for safety symbols and instructions before using.

1-22. RECOMMENDED TEST EQUIPMENT.

1-23. Required equipment to maintain the Model 3456A is listed in Table 1-2. Other equipment may be substituted if it meets the requirements listed in the table. The table is also repeated in Section IV of the Operating and Service Manual.

Table 1-1. Specifications.

DC VOLTAGE						
Input Characteristics						
Range	Maximum Reading (5 digit)	6 Digit	Resolution 5 Digit	4 Digit	Input Resistance	Maximum Input Voltage
0.1V	.119999V	100 nV	1 μ V	10 μ V	> 10 ¹⁰ Ω	± 1000V peak
1.0V	1.19999V	1 μ V	10 μ V	100 μ V	> 10 ¹⁰ Ω	
10.0V	11.9999V	10 μ V	100 μ V	1mV	> 10 ¹⁰ Ω	
100.0V	119.999V	100 μ V	1mV	10mV	10M Ω ± .5%	
1000.0V	1000.00V	1mV	10mV	100mV	10M Ω ± .5%	

Guard to Chassis: ± 500V peak
Guard to Low: + 200V peak

Measurement Accuracy: ± (% of Reading + Number of Counts).
Auto-zero on and filter off.

24 hours: 23°C ± 1°C

Range	6 Digit (≥ 10 PLC ¹)	6 Digit (1 PLC)	5 Digit (.1 PLC)	4 Digit (.01 PLC)
0.1V	.0022 + 24	0.0024 + 32	0.007 + 14	0.06 + 3
1.0V	0.0009 + 4	0.0012 + 5	0.007 + 3	0.06 + 2
10.0V	0.0008 + 2	0.0011 + 3	0.007 + 2	0.06 + 2
100.0V	0.0011 + 3	0.0014 + 4	0.007 + 2	0.06 + 2
1000.0V ¹	0.0011 + 2	0.0013 + 3	0.007 + 2	0.06 + 2

90 Day: 23°C ± 5°C

Range	6 Digit (≥ 10 PLC)	6 Digit (1 PLC)	5 Digit (.1 PLC)	4 Digit (.01 PLC)
0.1V	0.0034 + 24	0.0035 + 32	0.008 + 14	0.06 + 3
1.0V	0.0024 + 4	0.0025 + 5	0.007 + 3	0.06 + 2
10.0V	0.0023 + 2	0.0024 + 3	0.007 + 2	0.06 + 2
100.0V	0.0026 + 3	0.0027 + 4	0.007 + 2	0.06 + 2
1000.0V ¹	0.0024 + 2	0.0025 + 3	0.007 + 2	0.06 + 2

¹Add .012 $\left(\frac{\text{Input Voltage}}{1000}\right)^2$ % to % reading.

> 90 days: 23°C ± 5°C
Add ± .0006% of Reading/month to 90 day accuracy.

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

Temperature Coefficient: (5 digit)² ± (% of Reading + Number of Count)/°C

Range	0.1V	1.0V	10.0V	100.0V	1000.0V
Temp. Coef.	0.0002 + 0.2	0.0002 + 0.02	.0002 + .002	0.0002 + 0.02	0.0002 + 0.02

Auto-Zero OFF: (5 digit)²

For a stable environment ± 1°C, add 10 counts for .1V range, 1 count for 1V and 100 ranges, and .1 count for 10V and 1000V ranges.

Filter ON: Rejection is > 60 dB at 50 Hz. Add 2µV for .1V, 1.0V and 10V range and 200 µV for 10V and 1000V range.

²For 6 digits, multiply counts by 10
For 4 digits, multiply counts by .1

Response Time:

Filter OFF - For default delay (0.0 seconds), error is < .0005 % of input voltage step.

Filter ON: For default delay (.65 seconds), error is < .01 % of input voltage step.

Integration Time in Power Line Cycles (PLC)	Noise Rejection (dB)		
	AC ^{3, 4} NMR	AC ^{3, 4} ECMR ⁴	DC ECMR ⁴
.01 PLC or .1 PLC	0	90	140
> 1 PLC	60	150	140
> 1 PLC with Filter	120	160	140

*Integration in POWER LINE CYCLES

³For 50, 60 Hz (depending on option) ± .09%.

⁴1 KΩ unbalance in Lo

AC RMS VOLTAGE

Input Characteristics

Range	Maximum Reading (5 Digit)	6 Digit	Resolution 5 Digit	4 Digit	Input Impedance	Maximum Input Voltage
1.0V	1.19999V	1 µV	10 µV	100 µV	1MΩ ± .5% shunted by < 75pF	± 1000V peak (700V rms) 10 ⁸ VHZ
10.0V	11.9999V	10 µV	100 µV	1mV		
100.0V	119.999V	100 µV	1mV	10mV		
1000.0V	700.00V	1mV	10mV	100mV		

Guard to Chassis: ± 500V peak
Guard to Low: ± 200V peak

Measurement Accuracy: ± (% of Reading + Number of Counts)

Auto-zero on, > 1% of full scale, and DC component < 10% of AC Component.

For inputs > 500V rms add .07% of reading.

24 hours: 23°C ± 1°C

Integration Time in Power Line Cycles (PLC)	Frequency in Hz				
	Filter Off → 20 to 30	400-20k 30-20k	20k to 50k 20k to 50k	50k to 100k 50k to 100k	¹ 100k to 250k ¹ 100k to 250k
6 Digit (≥ 1 PLC)	.33 + 300	.05 + 550	.15 + 1500	.53 + 2700	5.0 + 6300
5 Digit (.1 PLC)	.34 + 33	.06 + 55	.16 + 150	.54 + 270	5.0 + 630
4 Digit (.01 PLC)	.39 + 5	.11 + 7	.21 + 17	.59 + 29	5.1 + 65

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

90 day: 23°C ± 5°C

Integration Time in Power Line Cycles (PLC)	Frequency in Hz				
	Filter Off → 20 to 30	400-20k 30-20k	20k to 50k 20k to 50k	50 k to 100k 50k to 100k	¹ 100k to 250k ¹ 100k to 250k
6 Digit (≥ 1 PLC)	.35 + 500	.07 + 700	.17 + 1700	.55 + 2900	5.0 + 6500
5 Digit (.1 PLC)	.36 + 53	.08 + 73	.18 + 173	.56 to 293	5.0 + 653
4 Digit (.01 PLC)	.41 + 7	.13 + 9	.23 + 19	.61 + 31	5.1 + 67

¹Frequencies > 100 kHz are specified for 1.0V and 10V ranges only.

> 90 day: 23°C ± 5°C (5 digit)²

Add ± (.004% of Reading + 12 counts)/month to 90 day accuracy.

Temperature Coefficient: (5 digit)²

± (% of Reading + Number of Counts)/°C

± (.008 + 6)/°C for DC component < 10% AC component

± (.008 + 12)/°C otherwise

²For 6 digit, multiply counts by 10.

For 4 digit, multiply counts by .1.

DC Component > 10% of AC Component: (5 digit)²

Add ± (.05% of Reading + 50 counts) to accuracy.

Crest Factor: > 7 at full scale.

Common Mode Rejection (1kΩ unbalance in Lo): > 90 dB DC to 60 Hz

Auto-Zero Off: For stable environment ± 1°C no accuracy change.

Default Delays:

Filter Off - .06 seconds

Filter On - .80 seconds

Response Time: For default delay, error is < .1% of input voltage step.

RESISTANCE

Input Characteristics

Range	Maximum Reading (5 Digit)	6 Digit	Resolution 5 Digit	4 Digit	Current Through Unknown	Maximum Valid Reading Voltage	Maximum Open Circuit Voltage
100Ω	119.9999Ω	100μΩ	1mΩ	10mΩ	1mA	1.2V	5.5V
1kΩ	1199.999Ω	1mΩ	10mΩ	100mΩ	1mA	1.2V	5.5V
10kΩ	11.99999kΩ	10mΩ	100mΩ	1Ω	100μA	1.2V	5.5V
100kΩ	119.9999kΩ	100mΩ	1Ω	10Ω	50μA	6V	9.5V
1MΩ	1199.999kΩ	1Ω	10Ω	100Ω	5μA	6V	9.5V
10MΩ	11.99999MΩ	10Ω	100Ω	1kΩ	500nA	6V	9.5V
100MΩ	119.9999MΩ	100Ω	1kΩ	10kΩ	≤ 500nA ¹	5V	5.5V
1GΩ	1000.000MΩ	1kΩ	10kΩ	100kΩ	≤ 500nA ¹	5V	5.5V

¹Ohms source is a 500nA current source in parallel with a 10MΩ resistance.

Non-destructive overload: 350V peak.

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

Measurement Accuracy: ± (% of Reading + Number of Counts)
Auto-Zero on, filter off, and 4-wire ohms.

24 hours: 23°C ± 1°C

Range	6 Digit (≥ 10 PLC)	6 Digit (1 PLC)	5 Digit (.1 PLC)	4 Digit (.01 PLC)
100Ω	0.003 + 24	0.003 + 32	0.009 + 14	0.07 + 3
1kΩ	0.002 + 4	0.003 + 5	0.008 + 3	0.07 + 2
10kΩ	0.002 + 4	0.003 + 5	0.008 + 3	0.07 + 2
100kΩ	0.002 + 2	0.003 + 3	0.008 + 2	0.07 + 2
1MΩ	0.006 + 2	0.006 + 3	0.012 + 2	0.07 + 2
10MΩ	0.041 + 2	0.041 + 3	0.07 + 2	0.12 + 2
100MΩ	1.3 + 1	1.3 + 1	1.5 + 1	1.5 + 1
1GΩ	11 + 1	11 + 1	13 + 1	13 + 1

90 days: 23°C ± 5°C

Range	6 Digit (≥ 10 PLC)	6 Digit (1 PLC)	5 Digit (.1 PLC)	4 Digit (.01 PLC)
100Ω	0.004 + 24	0.004 + 32	0.01 + 14	0.07 + 3
1kΩ	0.003 + 4	0.004 + 5	0.009 + 3	0.07 + 2
10kΩ	0.003 + 4	0.004 + 5	0.009 + 3	0.07 + 2
100kΩ	0.003 + 2	0.004 + 3	0.009 + 2	0.07 + 2
1MΩ	0.007 + 2	0.007 + 3	0.013 + 2	0.07 + 2
10MΩ	0.042 + 2	0.042 + 3	0.07 + 2	0.12 + 2
100MΩ	1.8 + 1	1.8 + 1	2.0 + 1	2.0 + 1
1GΩ	16 + 1	16 + 1	18 + 1	18 + 1

> 90 days: 23°C ± 5°C
Add ± .0004% of Reading/month to 90 day accuracy.

2-Wire Ohms Accuracy: Same as 4-wire ohms except add < .2 ohm offset.

Auto-Zero Off Accuracy: (5 digit)²
For a stable environment ± 1°C, add 10 counts for 100Ω range, 1 count for 1kΩ range and 10kΩ ranges, and .2 counts for ≥ 100kΩ ranges. Changes in lead resistance are not corrected for a 4-wire ohms.

²For 4 digit, multiply counts by .1.
For 6 digit, multiply counts by 10.

Range	Maximum Lead Resistance for 4-Wire Ohms	Maximum Offset Voltage for Offset Compensated Ohms	Default Delay in Seconds
100Ω	10Ω	.01V	0
1kΩ	100Ω	.1V	0
10kΩ	1000Ω	.1V	0
100kΩ	1000Ω	.5V	.001
1MΩ	1000Ω		.008
10MΩ	1000Ω		.08
100MΩ	1000Ω		.08
1GΩ	1000Ω		.08

Offset Compensated Ohms Accuracy: Same as 2-wire and 4-wire except maximum reading may be reduced by 9% for large offset voltages. 100Ω - 100kΩ range are used.

Response Time: With default delay and < 200pF of capacitance, first reading is in specification.

Filter is not operational in ohms.

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

Temperature Coefficient: (5 digit)² ± (% of Reading + Number of Counts)/°C

Range	100Ω	1kΩ 100kΩ	1MΩ	10MΩ	100MΩ	1GΩ
T.C.	.0004 +.2	.0004 +.02	.0004 +.004	.0010 +.004	.16 +0	1.6 +0

READING RATE

Reading rates are with autorange, math, display and filter off. Output is to internal memory using internal trigger and packed Mode. Packed output in place of internal memory adds .35 msec; ASCII output adds 2.3 msec.

Rates vs. Integration Time and Auto-Zero: DC Volts and 100Ω thru 10kΩ ranges with default (-0.0 sec.) delay. Also, AC or AC+DC Volts and 100kΩ thru 10MΩ ranges with 0.0 sec. delay.

Integration Time in Power Line Cycles (PLC)	Rates			
	Auto-Zero Off		Auto-Zero On	
	60 Hz	50 Hz	60 Hz	50 Hz
0.01	330	290	210	180
.10	210	180	120	100
1.00	48	40	25	20.8
10.00	5.8	4.8	2.9	2.4
100.00	.57	0.47	.29	0.24

RATIO

Type: DC/DC, AC/DC, or (AC+DC)/DC

Method: 4-Wire with Volts Lo input common.

$$\text{Ratio} = \frac{\text{Signal Voltage}}{\text{Ref. Hi Voltage} - \text{Ref. Lo Voltage}}$$

Signal Measurement: Same as DC Volts, or AC+DC Volts.

Reference Measurement: Automatically selects .1V, 1V, or 10V DC Volts range and a 0.0 msec. settling time. Filter is off.

Maximum Reference Voltage:

- Ref. Hi: ± 12V
- Ref. Lo: ± 9% of Ref. Hi.
- Ref. Hi-Ref. Lo: ± 11.9999V
- Protection: ± 350V peak

Accuracy: Total % signal error + total % reference error (same as .1V, 1V, or 10V DC volts)

Rates with 1 Power Line Cycle Integration and Default Delays.

	Rates	
	60 Hz	50 Hz
- DC Volts and 100Ω thru 10kΩ, Auto-zero Off	48.0	40.00
- DC Volts, Filter ON	1.48	1.47
- AC or AC+DC Volts, Auto-zero OFF	12.0	11.00
- AC or AC+DC Volts, Filter ON	1.2	0.95
- 100kΩ range, Auto-zero OFF	46.0	35.0
- 1MΩ range, Auto-zero OFF	34.0	28.0
- 10MΩ range, Auto-zero OFF	9.9	9.0
- 100MΩ and 1GΩ range, Auto-zero OFF	6.6	6.10
- DC/DC ratio	5.2	4.40
- Offset Compensated Ohms	10.0	9.00

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

MATH FUNCTION SPECIFICATIONS

General: Math function specifications do not include error in X (instrument reading) or in entered values (R,L,U,Y,Z). Range of values input or output is ± (0.000000 x 10⁻⁹ to 1999999 x 10⁹). Out of range values send "LL" to display and + 1999999. x 10⁹ to HP-IB.

PASS/FAIL: Displays: "HI" for values > upper limit (U), "LO" for values < lower limit (L), and X for values between the limits, with no introduced error.

SRQ mask can be programmed to respond to HI or LO conditions.

Maximum execution time: 20ms

STATISTICS:

$$\text{Mean (M)} = X_1 + \frac{1}{C} \sum_{i=1}^C (X_i - X_1)$$

$$\text{Variance (V)} = \frac{\sum_{i=1}^C (X_i - X)^2}{C - 1} - \frac{1}{C} \left[\sum_{i=1}^C (X_i - X_1) \right]^2$$

Maximum (U) and Minimum (L) are the most positive and negative instrument readings, respectively. X is displayed during calculation of statistics.

X₁ is the first reading taken after enabling statistics and is stored in the Z register. The number of readings taken (C) is stored in the count register.

$$\text{Accuracy of Mean: } < \pm \frac{C(U-L)}{10^{11}} + 1 \text{ LSD}$$

$$\text{Accuracy of Variance: } < \pm \frac{C(U-L)^2}{10^8} + 1 \text{ LSD}$$

Maximum execution time: 50ms

NULL: X - X₁ (X₁ is the first valid reading taken after enabling null and is stored in the Z register).

Maximum execution time: 15ms

dBm(R): 10 log $\frac{X^2/R}{1mW}$ R is the user-entered impedance.

Output range: -280 to +340 dBm

Accuracy: ± .001 dBm

Maximum execution time: 150ms

THERMISTOR (°F): Converts resistance of thermistor HPO837-0164 to temperature in °F.

Output range: -112 to 302°F

Accuracy: -103 ≤ T ≤ +266 °F: ± 11°F max.
-116 ≤ T ≤ +320°F: ± 27°F max.

Maximum execution time: 150ms

THERMISTOR (°C): Converts resistance of thermistor HPO837-1064 to temperature in °C.

Output range: -80 to 150°C

Accuracy: -75 ≤ T ≤ +130°C ± 06°C max.
-80 ≤ T ≤ +150°C ± 15°C max.

Maximum execution time: 100ms

SCALE: (X-Y)/Y

Accuracy: ± 1 LSD

Maximum execution time: 60ms

% ERROR: 100% x (X-Y)/Y

Accuracy: ± 1 LSD

Maximum execution time: 60ms

dB: 20 log $\frac{X}{Y}$

Output Range: -620 to +620 dB

Accuracy: .001 dB

Maximum execution time: 100ms

MEMORY

Reading Store:

- Can store up to 350 most recent readings.
- Can be recalled from the HP-IB interface or the front panel.

Program Memory:

- Can execute an internal program which controls instrument configuration and measurement sequence.
- Program is input from the HP-IB interface with up to 1400 ASCII characters.

Memory Size:

- Total size = 1400 bytes
- Memory used = 1 byte per ASCII character + 4 bytes per reading stored.

GENERAL

Voltmeter Control Functions: Description: The voltmeter control function in the math section of the front panel is designed to control the measurement parameters of the 3456A. Included in this front panel section is the:

- 1) Number of digits displayed.
- 2) Number of readings per trigger.
- 3) Delay time between readings.
- 4) Integration time in number of power line cycles (PLC).

Number of Digits Displayed allows selection of 3 to 6 digits displayed plus sign and exponent. The range of the display is ± 1,999,999 ± 9.

Number of Readings per Trigger allows selection of specific number of readings to be taken with just one trigger. The time between readings is controlled by the delay time selected.

Delay Time allows selection of the time between measurement cycles. It is provided to allow the selection of settling time. The range is from 0 to 999,999 sec. in 0.001/sec. increments. Accuracy is 1% of time selected.

Integration Time in Power Line Cycles allows the selection of the time for measurement integration. The units of integration time in power line cycles (PLC) apply for both 50 and 60 Hz power line frequencies. The range of integration time selection is from 0.01 to 100 power line cycles (PLC) per measurement.

Front-Rear Terminal Switch - On the front panel. Operated manually. Its status can be read via software.

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

<p>The actual measurement time is a function of the integration time, the delay time, auto zero, filter, etc., voltmeter complete, external trigger, and function selected.</p> <p>Operating Temperature: 0 C to 50 C</p> <p>Warmup Time: One hour to meet all specifications</p> <p>Humidity Range: 95% R.H., 0 C to 40 C</p>	<p>Storage Temperature: -40 C to +75 C</p> <p>Power: 100/120/240V + 5%, -10% 48 Hz to line operation 80VA; 220V ± 10% 48 Hz to line operation 80VA.</p> <p>Size: 88.9mm high x 425.5mm wide x 527.1mm deep (3½" high x 16¾" wide x 20¾" deep)</p> <p>Weight: Net 10.49 kg (23.13lbs.)</p>
---	---

Table 1-2. Recommended Test Equipment

Instrument	Critical Specification	Recommended Model	Use
DC Voltage Standard	Voltage: 10mV to 1000V Accuracy: ±.005%	Systron Donner Model M107	PAT
DC Transfer Standard	Output Voltages: 1V, 10V, 1.018V, 1.019V Accuracy: ± 5ppm Stability: ± .001% (30 Days)	Fluke Model 731B	PA
AC Calibrator	Frequency: 20 Hz to 250 kHz Output Level: 100mV to 1000V Accuracy: ± .1% Voltage Stability (6 mos.) ± .02%	Fluke Model 5200A and Model 5215A	PAT
Reference Divider	Division Ratio Accuracy: ± .001% Output Voltage Range: 1V to 1kV	Fluke Model 750A	PA
Resistance Standard	Resistance: 100Ω Accuracy: ± .0005%	Guidline Model 9330/100 or 9330A/100	P
	Resistance: 1kΩ Accuracy: ± .0005%	9330/1K or 9330A/1K	PA
	Resistance: 10kΩ Accuracy: ± .001%	9330/10K or 9330A/10K	PA
	Resistance: 100kΩ Accuracy: ± .001%	9330/100K or 9330A/100K	PA
	Resistance: 1MΩ Accuracy: ± .002%	9330/1M	PA
	Resistance: 10MΩ Accuracy: ± .01%	9330/10M	PA
	Resistance*: 1GΩ Accuracy: ± 2%	-hp- Part No. 03456-67902	P
DC Null Voltmeter	Voltage Range: 1μV to 10V	-hp- Model 419A	PA
Bus System Analyzer**	HP-IB Control Capability	-hp- Model 59401A	T
Desktop Computer	HP-IB Control Capability serves as printer for output data	-hp- Model 9825A, 9825B, 9835A, 9845B, or 85A	OT
Oscilloscope**	Bandwidth: DC to 100 MHz Sweep Time: 50ns to 20ms/div	-hp- Model 1740A	T
Digital Voltmeter**	Voltage Range: 100μV to 1000V Resolution: 1 μV	-hp- Model 3456A (or 3455A)	T
Resistors	Resistances: 1 kΩ ± 10%	-hp- Part No. 0684-1021	
Signature Analyzer**		-hp- Model 5004A	T
Test Program Cartridges*		-hp- Part Number 03456-10001 (9825A/B) 03456-10002 (9835A, 9845A/B) 03456-10003 (85A)	T

Table 1-2. Recommended Test Equipment (Cont'd).

Instrument	Critical Specification	Recommended Model	Use
Isolation Logic Test Jumper* HP IB Signature Analysis Modules*,**		-hp- Part No. 03456-61602 -hp- Part Number 5061-1153 5061-1154 5061-1155	T T
<p>*These items included in 3456A Digital Voltmeter Service Kit for Component Level Repair (-hp- Part Number 03456-69800)</p> <p>**These items are not required if a board level repair strategy is to be used. This strategy does require a 3456A Digital Voltmeter Service Kit for Board Level Repair (-hp- Part Number 03456-69801).</p> <p style="text-align: center;">P = Performance Test T = Troubleshooting A = Adjustment O = Operators Check</p>			

SECTION II INSTALLATION

2-1. INTRODUCTION.

2-2. This section of the manual contains the necessary information and instructions to install and interface the Model 3456A Digital Voltmeter. Included are initial inspection procedures, power and grounding requirements, environmental information, and instructions for repacking the instrument for shipment.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be free of marks or scratches and in perfect electrical order upon receipt. The instrument should be inspected for any damage that may 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 checking the electrical performance of the 3456A are given in Section IV. If there is mechanical damage, or the contents are incomplete, or the instrument does not pass the performance tests, notify the nearest Hewlett-Packard Office (a list of the -hp- Sales and Service Offices is located 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 3456A requires a power source of 100, 120, 220, or 240 V ac (-10%, +5%), 48 Hz to 66 Hz single phase. Maximum power consumption is 80 VA.

2-8. Line Voltage Selection.

2-9. Figure 2-1 provides information for line voltage and fuse selection. Make sure the rear panel line selector switches are in the correct position and the correct fuse is installed in the 3456A, before applying ac power to the instrument.

2-10. Power Cords and Receptacles.

2-11. Figure 2-2 illustrates the different power plug configurations that are available to provide ac power to the 3456A. The -hp- part number shown directly below the individual power plug drawing is the part number

for the power cord set equipped with the appropriate mating plug for that receptacle. If the appropriate power cord is not included with the instrument, notify the nearest -hp- Sales and Service Office and a replacement cord will be provided.

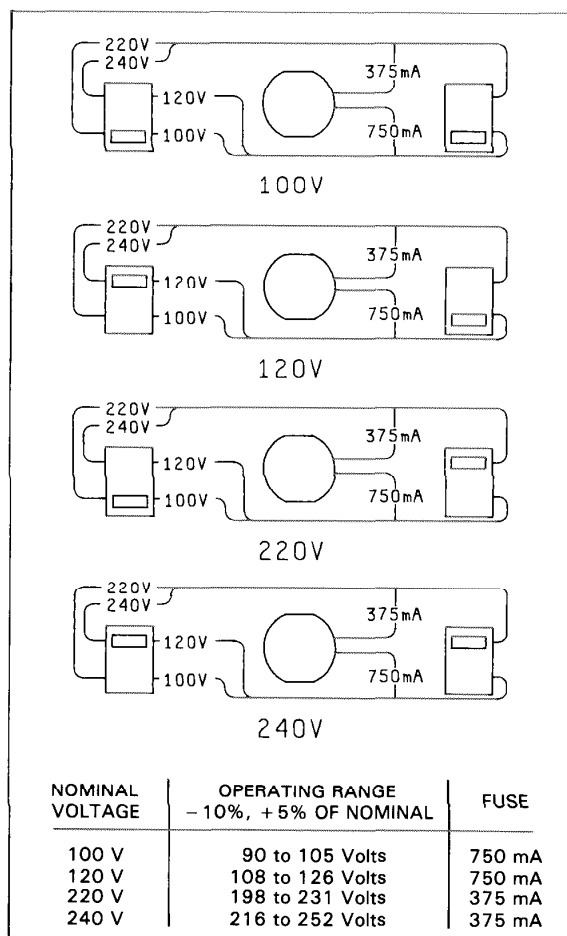


Figure 2-1. Line Voltage Selection.

2-12. Grounding Requirements.

2-13. To protect operating personnel, the National Electrical Manufacturer's Association (NEMA) recommendation is to ground the instrument panel and cabinet. The -hp-Model 3456A is equipped with a three conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument.

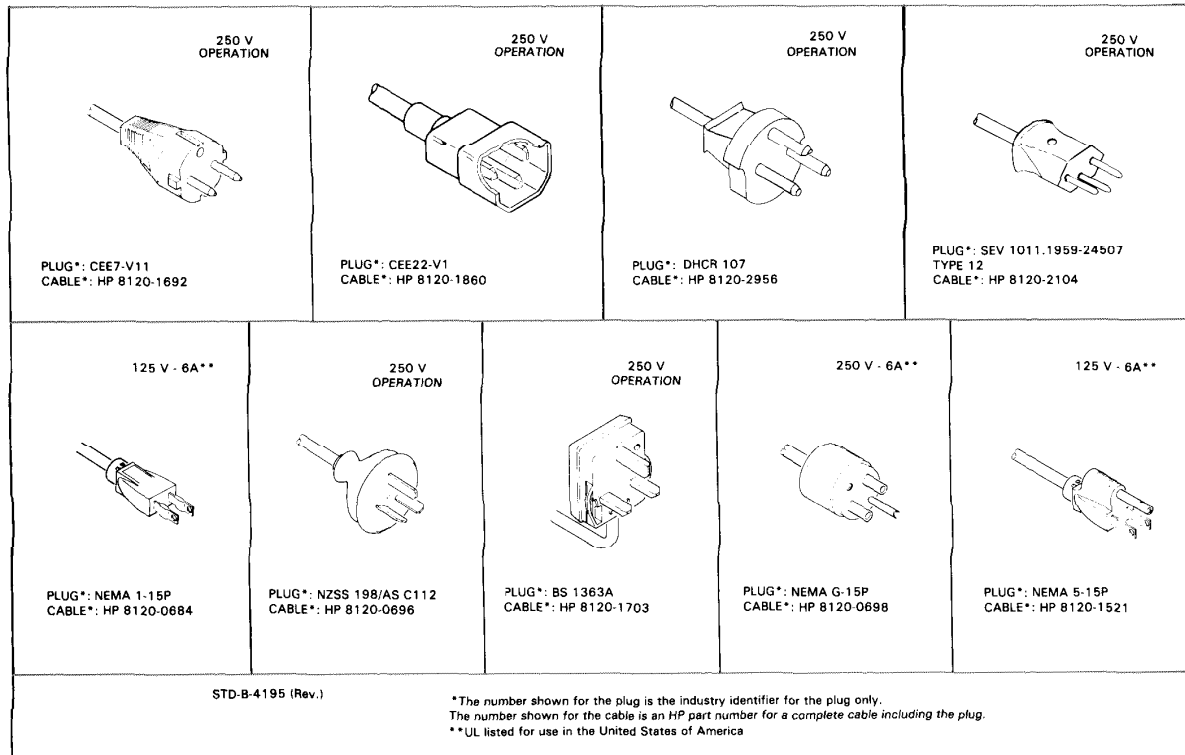


Figure 2-2. Power Cables.

2-14. Bench Use.

2-15. The Model 3456A is shipped with feet and tilt stands installed and is ready for use as a bench instrument. The feet are shaped to permit "stacking" with other full-module Hewlett-Packard instruments.

2-16. Rack Mounting.

2-17. The -hp- Model 3456A can be rack mounted by adding rack mounting kit Option 908 or Option 909. The basic hardware and instructions for rack mounting are contained in Option 908 and addition of front handles to the basic rack mount kit are contained in Option 909. The rack mount kits are designed to permit mounting of the 3456A in a standard 19 inch rack, provided that sufficient rear support is available. Also make sure the air intake at the rear of the instrument is unobstructed.

2-18. Interface Connections.

2-19. The -hp- Model 3456A 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 3456A's HP-IB connection is made by an HP-IB Interface cable to the 24 pin HP-IB connector located at the rear panel. A typical interconnection of HP-IB is shown in Figure 2-3 in which system interconnection is made by three HP-IB Interface Cables. The ends of the cables have both a male and female connector to enable connections to other instruments and cables. As many as 15 instruments can be connected by the same interface bus. However, the maximum length of cable that can effectively be used to connect a group of instruments should not exceed 2 meters (6.5 feet) times the number of instruments to be connected, or 20 meters (65.6 feet), whichever is less. For a pictorial view of the HP-IB connector and its pin designation, refer to Figure 2-4.

2-20. Address Selection.

2-21. The HP-IB "talk" and "listen" address of the Model 3456A is set by the instrument's address switch, located at the rear panel. The talk and listen address is a 5-bit code which is selected to provide a unique address for each HP-IB instrument. The 3456A normally leaves the factory with the address switch set to decimal code "22." The corresponding ASCII code is a listen address code of "6" and a talk code of "V." Refer to Figure 2-5 for the factory address switch setting.

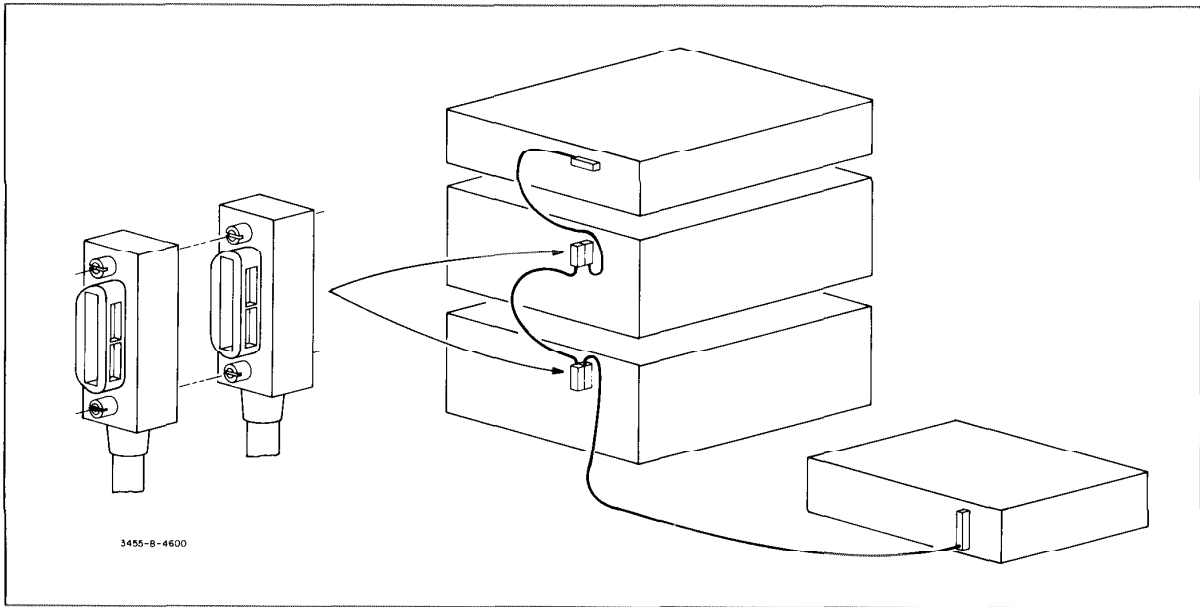


Figure 2-3. Typical HP-IB System Interconnections.

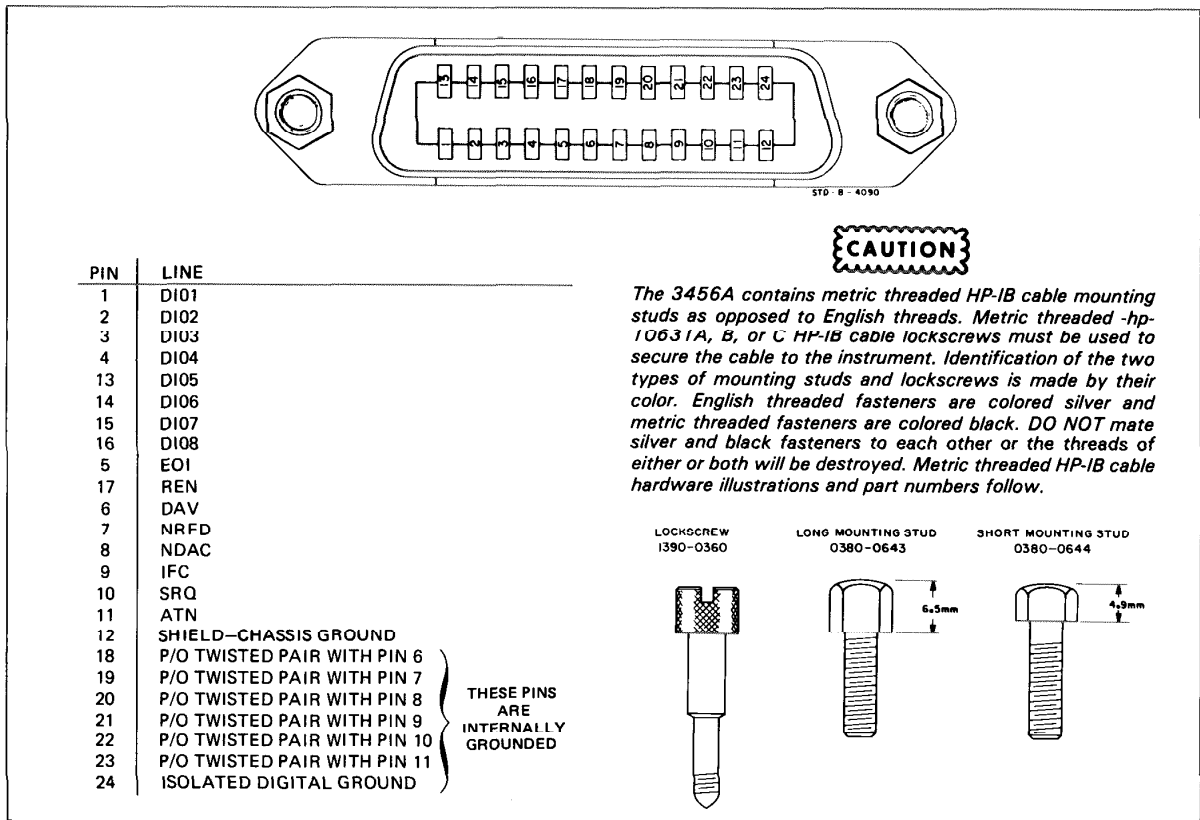


Figure 2-4. HP-IB Connector.

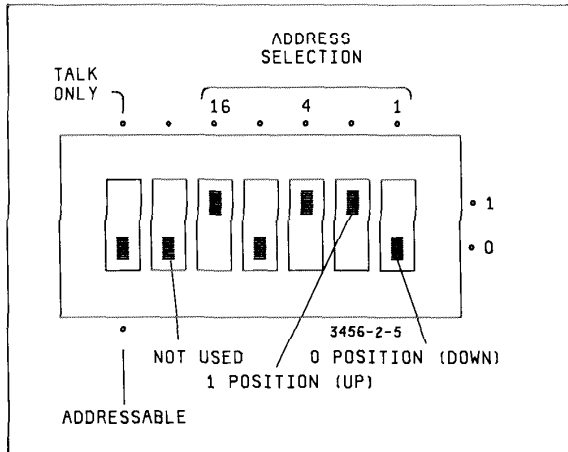


Figure 2-5. 3456A Address Switch.

NOTE

The 5-bit decimal code, consisting of bits A1 through A5, is often used by controllers which use this convention as a System Device Number for instruments.

2-22. "Talk-Only" mode. The instrument has a "Talk-Only" mode which can also be set by the address switch. The Remote Operation chapter in Section III of this manual gives a detailed description of the 3456A's "Talk-Only" mode, including the address codes.

2-23. External Trigger.

2-24. An External Trigger input to the 3456A is provided by a BNC connector located at the rear panel of the instrument. The trigger input should be driven by negative going TTL level signals. For more information refer to Section III in this manual.

2-25. Voltmeter Complete Connector.

2-26. A Voltmeter Complete output is also provided by the 3456A through a BNC connector located at the rear panel. This connector provides an output which is composed of a TTL level signal and is generated during a measurement cycle.

2-27. ENVIRONMENTAL REQUIREMENTS.

WARNING

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

2-28. Operating and Storage Temperature.

2-29. In order to meet and maintain the specifications listed in Table 1-1, the 3456A should be operated within an ambient temperature range of $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$ ($73^{\circ}\text{F} \pm 9^{\circ}\text{F}$). The instrument may be operated within an ambient temperature range of 0°C to 55°C ($+32^{\circ}\text{F}$ to 131°F) with less accuracy.

2-30. The 3456A may be stored or shipped within an ambient temperature range of -40°C to $+75^{\circ}\text{C}$ (-40°F to $+167^{\circ}\text{F}$).

2-31. Humidity.

2-32. The instrument may be operated in environments with relative humidity of up to 95%. The instrument must, however, be protected from temperature extremes which may cause condensation within the instrument.

2-33. Altitude.

2-34. The instrument may be operated at altitudes up to 4572 meters (15,000 feet).

2-35. 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 made. 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.

2-36. Place instrument in original container with appropriate packaging material and secure with strong tape or metal bands. If the original container is not available, a replacement container can be purchased from your nearest -hp- Sales and Service Office.

2-37. If the original container is not to be used, do the following:

1. Wrap the instrument in heavy plastic before placing in an inner container.
2. Place packing material around all sides of the instrument and protect the front panel with cardboard strips.
3. Place the instrument in the inner container in a heavy carton and seal with strong tape or metal bands.
4. Mark shipping container "DELICATE INSTRUMENT," "FRAGILE," etc.

SECTION III OPERATION

3-1. INTRODUCTION.

3-2. This is the information and instructions for the operation of the -hp- Model 3456A Voltmeter showing front panel and remote operations. In addition, you will find functional checks you can perform. For more advanced users a Quick Reference Guide is shipped with the instrument. The information in the guide is most of the 3456A's operating characteristics, including remote programming codes.

3-3. Before reading the operating information in this section, familiarize yourself with the front and rear panel features as indicated in Figure 3-1. Use the figure as a reference by folding the page out while reading this section.

3-4. Read the front panel operations of the 3456A before the remote operations since most front panel operations also apply to the remote operations.

3-5. PRE-OPERATING INSTRUCTIONS.

3-6. The 3456A's operation can be separated into five main areas. A good understanding of these areas is fundamental to learning the operation of the instrument. The five areas are:

- a. Reset and Test Operation.
- b. Function, Range and Trigger.
- c. Voltmeter Control Functions, (Delay, Number of Readings/Trigger, Number of Digits Displayed).
- d. Math.
- e. Remote Operation.

3-7. Refer to Figure 3-1. Note that the 3456A's front panel can be separated into three areas: Display, Voltmeter Configuration, and Numbered Keyboard. Keep these areas in mind when you use the 3456A.

3-8. To learn the operation of the instrument, a logical approach is to ask yourself the following questions:

- a. "What type of measurement do I want to make?" - FUNCTION
- b. "Do I want autoranging?" - RANGE

c. "Do I want the input filter in?" - FILTER

d. "Is a math operation desired?" - MATH FUNCTION

e. "Do I want remote control of the 3456A?" -REMOTE OPERATION

Once you have decided what you want the 3456A to do, the next step is to learn how to do it.

3-9. GENERAL OPERATING CHARACTERISTICS.

3-10. These paragraphs describe some of the 3456A's General Operating Characteristics. Refer to Figure 3-2, the Display Area, for the following discussion.

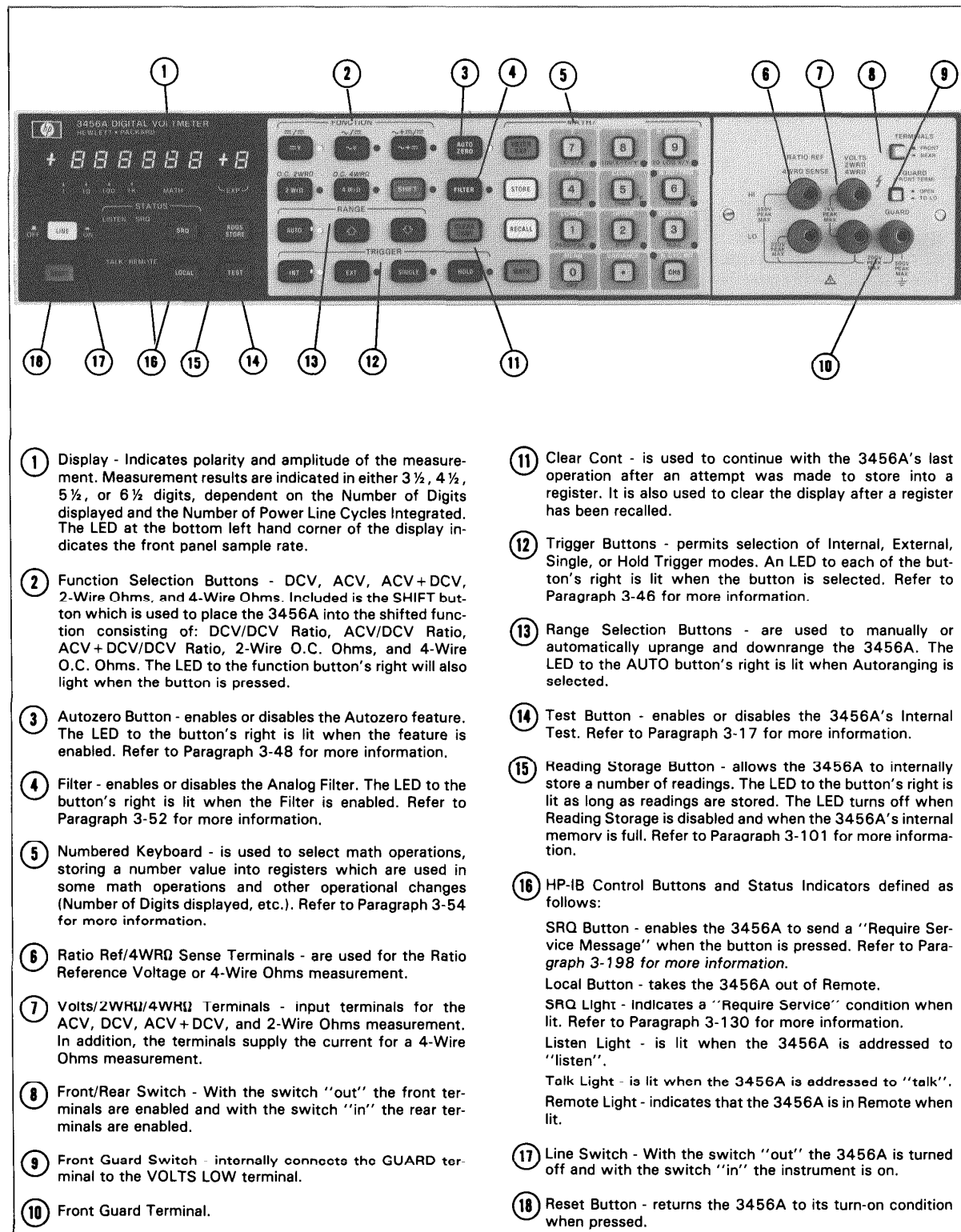
3-11. Turn-On and Warm-Up.

3-12. Before connecting ac power to the 3456A, make sure the rear panel line selector switches are set to correspond to the available power line voltage. Be certain the correct fuse is installed in the instrument. To meet accuracy specifications, the 3456A should be warmed up for at least one hour.

3-13. Reset.

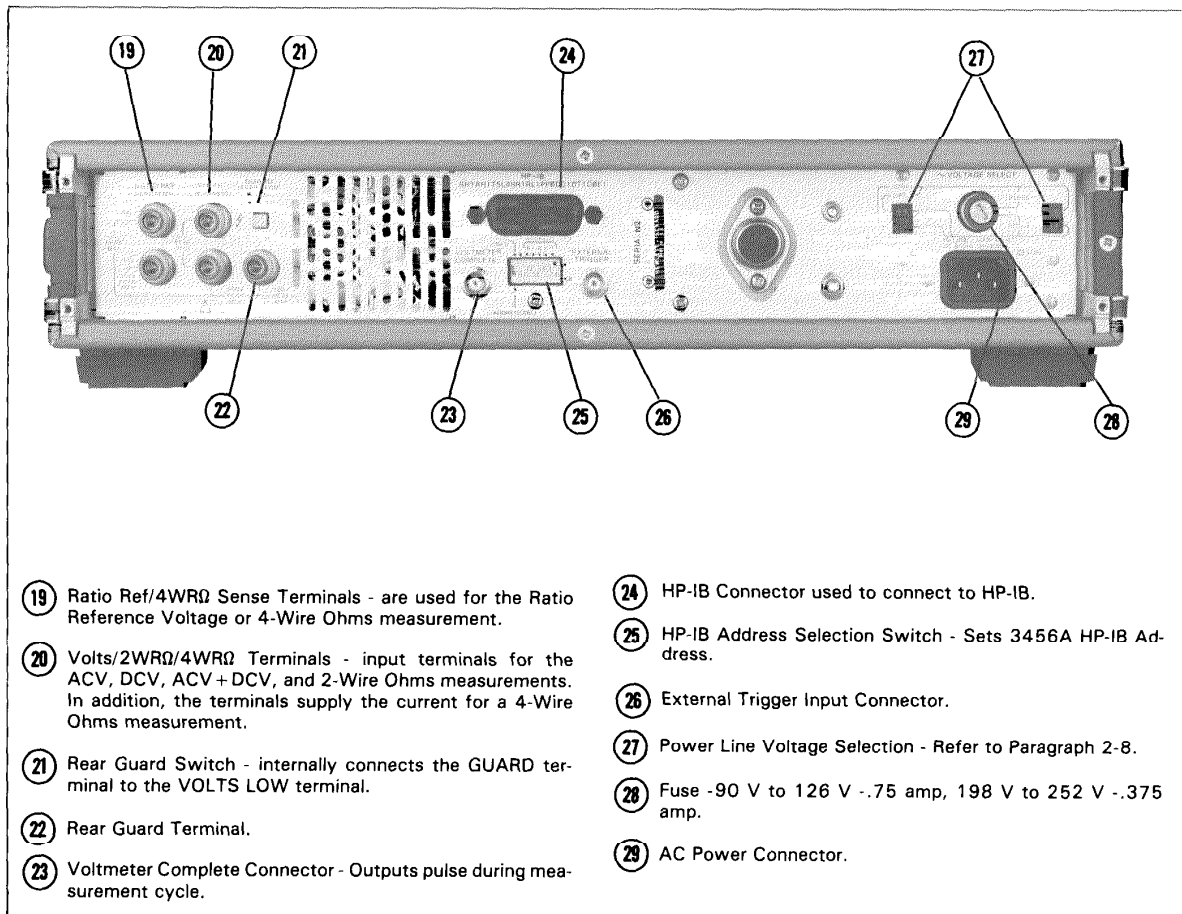
3-14. After power connection and warm-up, to make sure the instrument is in the "turn-on" state, press the RESET button. This places the instrument in the power-up condition without cycling power. This provides you a convenient starting place and avoids thermal and electrical shock to the instrument, therefore maintaining its accuracy and improving reliability. The turn-on state is:

FUNCTIONDC
RANGE AUTO
TRIGGER INTERNAL
MATH OFF
DELAYDEFAULT (0 SEC.)
NUMBER OF READ-
INGS/TRIGGER 1
NUMBER OF POWER
LINE CYCLES INT.10
NUMBER OF DIGITS DISPLAYED..... 5
AUTOZERO ON
OPERATING MODE.....LOCAL
FILTER OFF
READING STORAGE.....OFF



- ① Display - Indicates polarity and amplitude of the measurement. Measurement results are indicated in either 3 1/2, 4 1/2, 5 1/2, or 6 1/2 digits, dependent on the Number of Digits displayed and the Number of Power Line Cycles Integrated. The LED at the bottom left hand corner of the display indicates the front panel sample rate.
- ② Function Selection Buttons - DCV, ACV, ACV+DCV, 2-Wire Ohms, and 4-Wire Ohms. Included is the SHIFT button which is used to place the 3456A into the shifted function consisting of: DCV/DCV Ratio, ACV/DCV Ratio, ACV+DCV/DCV Ratio, 2-Wire O.C. Ohms, and 4-Wire O.C. Ohms. The LED to the function button's right will also light when the button is pressed.
- ③ Autozero Button - enables or disables the Autozero feature. The LED to the button's right is lit when the feature is enabled. Refer to Paragraph 3-48 for more information.
- ④ Filter - enables or disables the Analog Filter. The LED to the button's right is lit when the Filter is enabled. Refer to Paragraph 3-52 for more information.
- ⑤ Numbered Keyboard - is used to select math operations, storing a number value into registers which are used in some math operations and other operational changes (Number of Digits displayed, etc.). Refer to Paragraph 3-54 for more information.
- ⑥ Ratio Ref/4WRΩ Sense Terminals - are used for the Ratio Reference Voltage or 4-Wire Ohms measurement.
- ⑦ Volts/2WRΩ/4WRΩ Terminals - input terminals for the ACV, DCV, ACV+DCV, and 2-Wire Ohms measurement. In addition, the terminals supply the current for a 4-Wire Ohms measurement.
- ⑧ Front/Rear Switch - With the switch "out" the front terminals are enabled and with the switch "in" the rear terminals are enabled.
- ⑨ Front Guard Switch - internally connects the GUARD terminal to the VOLTS LOW terminal.
- ⑩ Front Guard Terminal.
- ⑪ Clear Cont - is used to continue with the 3456A's last operation after an attempt was made to store into a register. It is also used to clear the display after a register has been recalled.
- ⑫ Trigger Buttons - permits selection of Internal, External, Single, or Hold Trigger modes. An LED to each of the button's right is lit when the button is selected. Refer to Paragraph 3-46 for more information.
- ⑬ Range Selection Buttons - are used to manually or automatically uprange and downrange the 3456A. The LED to the AUTO button's right is lit when Autoranging is selected.
- ⑭ Test Button - enables or disables the 3456A's Internal Test. Refer to Paragraph 3-17 for more information.
- ⑮ Reading Storage Button - allows the 3456A to internally store a number of readings. The LED to the button's right is lit as long as readings are stored. The LED turns off when Reading Storage is disabled and when the 3456A's internal memory is full. Refer to Paragraph 3-101 for more information.
- ⑯ HP-IB Control Buttons and Status Indicators defined as follows:
 SRQ Button - enables the 3456A to send a "Require Service Message" when the button is pressed. Refer to Paragraph 3-198 for more information.
 Local Button - takes the 3456A out of Remote.
 SRQ Light - indicates a "Require Service" condition when lit. Refer to Paragraph 3-130 for more information.
 Listen Light - is lit when the 3456A is addressed to "listen".
 Talk Light - is lit when the 3456A is addressed to "talk".
 Remote Light - indicates that the 3456A is in Remote when lit.
- ⑰ Line Switch - With the switch "out" the 3456A is turned off and with the switch "in" the instrument is on.
- ⑱ Reset Button - returns the 3456A to its turn-on condition when pressed.

Figure 3-1. Front and Rear Panel Features.



- 19 Ratio Ref/4WRΩ Sense Terminals - are used for the Ratio Reference Voltage or 4-Wire Ohms measurement.
- 20 Volts/2WRΩ/4WRΩ Terminals - input terminals for the ACV, DCV, ACV + DCV, and 2-Wire Ohms measurements. In addition, the terminals supply the current for a 4-Wire Ohms measurement.
- 21 Rear Guard Switch - internally connects the GUARD terminal to the VOLTS LOW terminal.
- 22 Rear Guard Terminal.
- 23 Voltmeter Complete Connector - Outputs pulse during measurement cycle.
- 24 HP-IB Connector used to connect to HP-IB.
- 25 HP-IB Address Selection Switch - Sets 3456A HP-IB Address.
- 26 External Trigger Input Connector.
- 27 Power Line Voltage Selection - Refer to Paragraph 2-8.
- 28 Fuse -90 V to 126 V -.75 amp, 198 V to 252 V -.375 amp.
- 29 AC Power Connector.

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

3-15. When pressing the RESET button, the display will momentarily display this for about 1 second:

Add 022 0

3456A HP-IB Address in Decimal Talk-Only Indicator (0 = Normal Mode, 1 = Talk-Only Enabled)

See Paragraph 3-150 for the HP-IB address setting and Paragraph 3-154 for the "Talk-Only" mode.

3-16. When power is cycled, "HP 3456" is momentarily displayed and then the address code is displayed.

3-17. Self Test Operation.

3-18. The 3456A's Test Operation consists of certain analog gain, offset, and digital checks when the TEST button is pressed. Make sure the 3456A's input terminals are completely floated and the GUARD switch is in the "IN" position, when selecting the test operation. The test may not pass if external connections are

made to the input terminals, because certain input circuitry measurements are made. When the TEST button is pressed, the instrument displays

"+ 1.8.8.8.8.8. + 8."

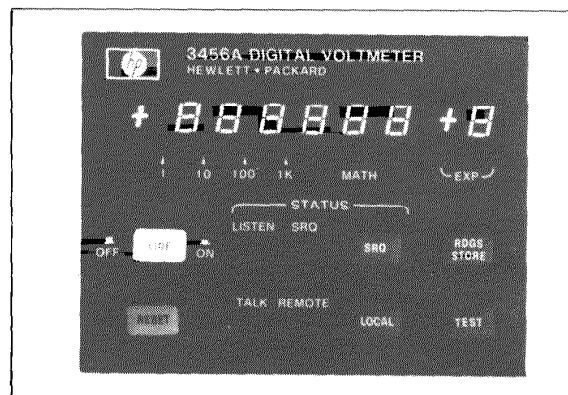


Figure 3-2. Front Panel Display Area.

and light all the front panel LEDs. This remains until the test is completed. Once the test is completed, the display and the LEDs go blank for a time and the test operation starts again. If any of the internal checks do not pass, a negative integer corresponding to the check which did not pass is displayed. The displayed number is also output over the HP-IB with the 3456A in remote. A '100' is output when the test passes. To disable the test operation press the TEST button a second time.

NOTE

Make sure no connection is made at the 3456A's Input Terminals and the GUARD switch is in the "IN" position during the Test mode.

NOTE

Refer the 3456A to a Service Trained Person, if the Internal Test does not pass.

3-19. Display.

3-20. Refer to Figure 3-3 to see how readings are displayed. Note that the 1 V through 1000 V ranges are displayed as they are measured with the decimal point in the correct place like this:

- 1.00000 – 1 V Range
- 10.0000 – 10 V Range
- 100.000 – 100 V Range
- 1000.00 – 1000 V Range

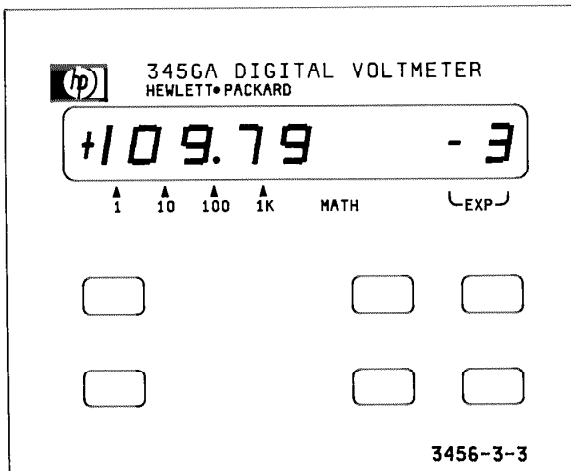


Figure 3-3. 3456A Display.

Additionally, a 1, 10, 100, and 1 K are marked on the front panel and are located below the decimal point of the respective ranges with the other ranges indicated in engineering notation. The position of the decimal point on the display marks the decade multiplier. The range is easily determined by multiplying the displayed exponent by the decade multiplier. For example:

decade multiplier — 1 0 9 . 7 9 -3
1 10 100 1K EXP
shows a reading of .10979 V or 109.79 mV. The decade multiplier is not used in the 3456A's Ratio and Math functions.

3-21. Error Messages.

3-22. Error Messages are displayed for invalid operating conditions. They are displayed like this:

E D

where "D" is the number indicating which error is generated. The instrument keeps displaying the Error Message until the condition producing the error is changed to a valid state. A listing of the various error messages is given in Table 3-1.

Table 3-1. Error Messages.

Error No.	Description
1	Autozero disabled in any Shifted Functions. Displayed in Remote only.
2	Analog Filter enabled in any Ohms Functions. Displayed in Remote only.
3	Any invalid Range and Function combination (Example: 10 M ohm Range selected for the DCV Function). Displayed in Remote only.
4	Attempt was made to store invalid number into a register (Example: a "9" is stored into the Number of Digits Displayed register).
5	Attempt was made to store any number into register C, M, or V.
6	Attempt was made to recall non-existent stored readings from memory.

3-23. OPERATING CHARACTERISTICS.

3-24. Refer to Figure 3-4, the front panel's Voltmeter Configuration area, for the following paragraphs.

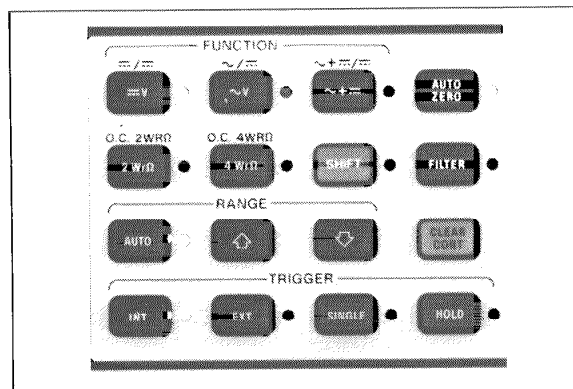


Figure 3-4. Front Panel Voltmeter Configuration Area.

3-25. DC Voltage Measurement.

3-26. The -hp- Model 3456A is capable of measuring dc voltages from 100 nanovolts through 1000 volts in five

ranges: 100 mV, 1 V, 10 V, 100 V, and 1000 V. All ranges are overload protected from input voltages up to 1000 V peak. The DCV input impedance is greater than 10^{10} ohms in the 100 mV to 10 V ranges and 10 M ohms in the 100 V and 1000 V ranges.

3-27. The measurement data can be displayed either as a $6\frac{1}{2}$, $5\frac{1}{2}$, $4\frac{1}{2}$, or a $3\frac{1}{2}$ digit reading, depending on the Number of Power Line Cycles Integrated (see Paragraph 3-61) and the Number of Digits selected (see Paragraph 3-63). Refer to Table 1-1 for accuracy specifications.

3-28. AC Voltage Measurement.

3-29. The -hp- Model 3456A uses a True RMS converter and is able to measure voltages from $1\ \mu\text{V}$ to 700 V RMS in four ranges: 1 V, 10 V, 100 V and 1000 V. All ranges are protected from input voltages up to 1000 V peak or 700 V RMS, whichever is less. Measurement data can be displayed either as a $6\frac{1}{2}$, $5\frac{1}{2}$, $4\frac{1}{2}$, or a $3\frac{1}{2}$ digit reading, depending on the selected Number of Power Line Cycles Integrated (see Paragraph 3-61) and the Number of Digits selected (see Paragraph 3-63). The frequency response of the converter is from 20 Hz to 250 kHz with a maximum input voltage of 1000 V peak (700 V RMS, 10^8 V/Hz). The input impedance of the converter is 1 M ohms shunted by $< 75\ \text{pF}$. Refer to Table 1-1 for accuracy specifications.

3-30. AC+DC Measurement.

3-31. The AC+DC mode of the 3456A measures the combined ac and dc components of the input signal and displays its RMS value. Other operating characteristics are the same as the ACV function. Refer to Table 1-1 for accuracy specifications.

3-32. One use of the AC+DC function is to determine the necessary power rating of an amplifier. Since many

amplifiers have ac signals with dc components, the true RMS value of those complex waveforms may need to be known. The AC+DC feature of the 3456A can simplify these measurements since it can measure the RMS value of the sum of the ac plus the dc voltage on the waveform.

3-33. Resistance Measurement.

3-34. The Model 3456A is capable of measuring resistance from 100 micro-ohm to 1 giga-ohm in eight ranges. The ranges extend from the 100 ohm full scale to the 1000 Meg-ohm full scale range. Resistance Measurement can be made using either the 2-wire or the 4-wire configuration. Refer to Figure 3-5 for the correct ohms connection.

3-35. Resistance Measurements can be displayed as either a $6\frac{1}{2}$, $5\frac{1}{2}$, $4\frac{1}{2}$, or a $3\frac{1}{2}$ digit reading, depending on the Number of Power Line Cycles Integrated (see Paragraph 3-61) and the Number of Digits selected (see Paragraph 3-63). The 4-WIRE ohm sense terminals are protected to a maximum level of 350 V peak. Refer to Table 1-1 for accuracy specifications.

3-36. The 3456A displays negative (minus) resistance under two conditions:

a. The inputs to the 4 WIRE SENSE (RATIO REF) or the 2WR Ω /4WR Ω (VOLTS) terminals are reversed from each other in 4-wire ohms function.

b. Small negative voltages on measuring circuitry.

NOTE

With the measuring leads shorting or when measuring small resistances, negative readings may be displayed due to offsets in the ohms circuitry.

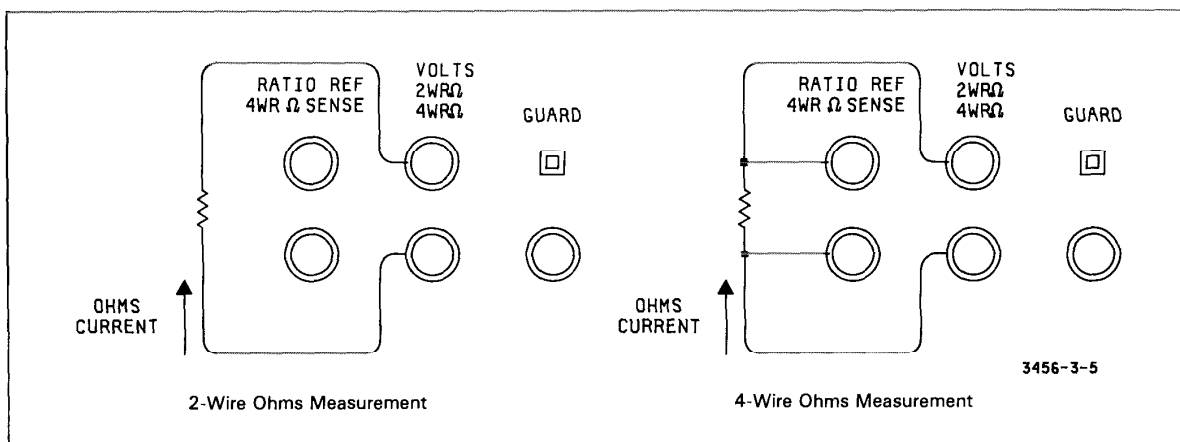


Figure 3-5. Ohms Connection.

NOTE

The 3456A's Analog Filter (see Paragraph 3-52) should not be used with any ohms functions. The filter is disabled when the ohms functions are selected from the front panel.

3-37. Shift Operation.

3-38. The purpose of the SHIFT button is to place the 3456A in the Shifted Functions. To disable the shifted functions, press the SHIFT button again. The SHIFT button's color is green and corresponds to the green lettering and symbols above the function buttons to identify shifted functions. All shifted functions readings are made by taking multiple measurements.

NOTE

The 3456A's Autozero feature (see Paragraph 3-48) is automatically enabled in front panel selectable shifted functions.

3-39. Ratio.

3-40. The -hp- Model 3456A can either make DCV/DCV, ACV/DCV, or ACV + DCV/DCV Ratio Measurements. This is done by taking a Signal, Reference High, and Reference Low Voltage reading which are all referenced to a common point, the VOLTS LOW terminal. The Signal Voltage is measured from the VOLTS HIGH terminal to the VOLTS LOW common. The Reference High Voltage is measured from the RATIO REF HIGH terminal to VOLTS LOW and the Reference Low Voltage is from the RATIO REF LOW terminal and VOLTS LOW. Refer to Figure 3-6 for a typical Ratio Measurement. Select the Ratio functions using the DCV, ACV, ACV + DCV function buttons in the shifted mode (press the SHIFT button). The green symbols above the function buttons identify the Ratio functions. Refer to Table 1-1 for accuracy specifications.

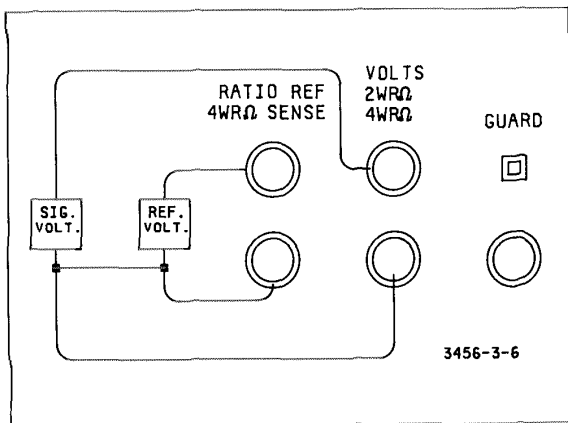


Figure 3-6. Ratio Connection.

a. Ratio Formula. A Ratio Measurement is a mathematical operation expressed in this formula:

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

The 3456A Ratio Measurement formula is:

$$\text{Ratio} = \frac{\text{Signal Voltage}}{\text{Reference High} - \text{Reference Low}}$$

Remember, the three voltages are referenced to the VOLTS LOW terminal. The Reference Low voltage should be kept low for an accurate Ratio measurement (within ± 9% of Reference High Voltage). The voltage can be kept low by shorting or otherwise connecting the RATIO REF LOW and VOLTS LOW terminals to each other, either at the terminals or measuring point.

NOTE

For a three wire Ratio Measurement connect the REFERENCE LOW and VOLTS LOW terminals to each other.

b. Ratio Measurement. For a Ratio Measurement the Reference Voltage can be between 0 to ± 12 V dc. The 12 V level is the maximum Reference Voltage level the instrument is able to measure (the RATIO REF terminals are protected up to 350 V peak). The Signal Voltage, which is applied at the VOLTS terminals, can either be dc, ac, or ac + dc volts from 0 to 1000 V peak or 700 V RMS. In addition, the Analog Filter (see Paragraph 3-52) and Delay (see Paragraph 3-67) are not used for the Reference Measurement. These features can be selected for the Signal Voltage Measurement. The following is a typical Ratio Measurement procedure.

1. Measure your Signal and Reference Voltages and make sure they are within the range for a Ratio Measurement (refer to Table 1-1 for the limits). Use the instrument's unshifted functions for those measurements.
2. Connect the Reference Voltage between the HIGH and LOW REFERENCE terminals.
3. Connect the Signal Voltage between the HIGH and LOW VOLTS terminals and connect RATIO REF LOW to VOLTS LOW.
4. Set the 3456A to the desired range or to Autorange.
5. Place the instrument into the Ratio mode by pressing the appropriate button (DCV/DCV, ACV/DCV, or ACV + DCV/DCV in the shifted mode).
6. Read the Ratio reading on the display.

NOTE

*It is important to remember that the **RATIO REF LOW** and **VOLTS LOW** terminals cannot be more than ± 12 V from each other.*

c. Typical Ratio Measurement. Matching resistor values for an accurate voltage divider is one way to use the 3456A's Ratio feature. Try this by using the set up in Figure 3-7. Connect the instrument as indicated in the figure. Make sure that REFERENCE LOW is connected at the top of R2 and that Signal (Volts) Common is connected at the bottom of R1. Once the instrument is connected and placed in the DCV/DCV Ratio mode, a Ratio Measurement is made. The voltage drop across R1 and R2 is measured including any offset voltages between Signal Common and Reference Low. The offset voltage is used to compensate for any error causing voltages between the input and resistors. Once all the measurements are taken, the Ratio Measurement is displayed on the front panel. If the resistors are equal in value, the reading should be approximately " -1.00000 ".

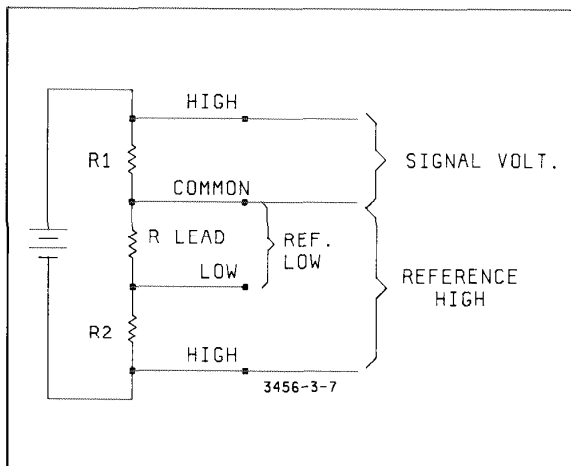


Figure 3-7. Typical Ratio Measurement.

3-41. Offset Compensated Ohms Measurement (O.C. Ohms).

3-42. This feature of the -hp- Model 3456A lets you take resistance measurements of components in the presence of small dc voltages. If this shifted function is selected, the instrument takes an ohms measurement and stores the reading into its internal memory. The ohms current source is then turned off and a dc reading is taken. This reading is subtracted from the previous reading and the resultant ohms reading is displayed on the front panel. Any small offset voltage on the measured component is compensated by the O.C. Ohms measurement. The maximum voltage level depends on the range selected (.01 V dc for the 100 ohm range, etc.). The O.C. Ohms ranges are from 100 ohm to 100 K ohm. Refer to Table 1-1 for the accuracy specifications.

NOTE

Due to internal switching in the 3456A, high capacitance(s) in parallel with the device or component being measured in the O.C. Ohms mode may cause erroneous readings.

3-43. You can use the O.C. Ohms feature of the 3456A to measure the contact resistance of a relay. Since some relay contacts may generate a small dc voltage (due to thermocouple effects), a normal ohms measurement technique may give incorrect readings. The O.C. Ohms feature subtracts this voltage from the ohms reading, and thereby gives an accurate resistance measurement of the relay.

3-44. Ranging.

3-45. The front panel range selection is controlled by three pushbuttons: the UPRANGE, DOWNRANGE, and AUTORANGE button. Their operation is as follows.

a. Uprange. The UPRANGE button's function is to set the 3456A to the next higher range, each time it is pressed. The highest selectable range depends on the function selected. For example, the 100 M ohm in the ohms function is not a valid range for the DCV or ACV functions and the 3456A defaults to the next highest valid range. The UPRANGE button is identified by an upward pointing arrow on its face.

b. Downrange. The function of the DOWNRANGE button is to set the 3456A to the next lower range, each time it is pressed. The lowest selectable range is the 100 mV or 100 ohms range. Similar to UPRANGE operation, the lowest range depends on the function. The ACV function, for example, has the 1 V range as the lowest range. If previously set to a lower range, the 3456A defaults to the 1 V range when the ACV function is selected. The DOWNRANGE button is identified by a downward pointing arrow on its face.

c. Autorange. With Autorange selected, the 3456A automatically selects the present reading's optimum range. Upranging is done when the reading is at or above 120% full scale. The downrange point is at or below 11% full scale. Try the following.

1. Place the 3456A into the Autorange mode; use a variable power supply and apply 1.0 V dc to the input. The range selected by the instrument is the 1 V range.
2. Increase the input voltage to > 1.2 V; the 3456A should then uprange to the 10 V range.
3. Decrease the input voltage to < 1.1 V; the instrument should then downrange back to the 1 V range.

d. Fast Autorange Feature. Autoranging by the 3456A is done quickly in both the upranging and downranging operations.

1. Upranging. When a voltage applied to the 3456A's input is higher than the range used at that time, an overload condition is detected. The overload condition is detected before the input measurement is complete. Upranging is done until the overload condition disappears and the optimum range is reached. Since the total measurement is never completed until the optimum range is reached, upranging is fast.
2. Downranging. Downranging is also done quickly by using a different method. When a non-overload measurement is made, the 3456A takes a complete measurement. Once the measurement is completed, the instrument then calculates the optimum range from the reading. A maximum of three ranges can be skipped at one time, enabling the 3456A to downrange quickly.

3-46. Instrument Trigger Modes.

3-47. The -hp- Model 3456A has four trigger modes: Internal Trigger, External Trigger, Single Trigger, and Hold. A description of each mode is as follows.

a. Internal Trigger. This trigger is internally generated by the 3456A and is used to initiate a measurement cycle. The instrument is placed into the Internal Trigger mode by pressing the INT (Internal Trigger) pushbutton located on the front panel. This trigger is also automatically selected when the RESET button is pressed and at turn on.

b. External Trigger. In the External Trigger mode, the instrument can be triggered by an externally applied trigger pulse. The pulse is applied to the External Trigger Input connector located on the rear panel and should be at least 500 nsec wide. The External Trigger Input is TTL compatible with actual instrument triggering occurring on the falling (negative) edge. By application of the pulse, the 3456A triggers and initiates a measurement cycle. After this cycle is completed, the instrument can be triggered again for a new cycle. If any triggering is done during the measurement cycle, the trigger is ignored until the cycle is completed. To start a new measurement, the 3456A has to be triggered again.

c. Single Trigger. The Single Trigger operation is similar to the External Trigger operation with triggering being accomplished by the front panel's SINGLE trigger pushbutton. Depressing the button first places the 3456A into the Signal Trigger mode (if the 3456A is in another trigger mode) and then triggers the instrument. A measurement cycle is then initiated. If the pushbutton is pressed again during the cycle, a new measurement cycle is started. The 3456A can be triggered again by depressing the SINGLE trigger pushbutton.

d. Hold. The Hold operation prevents the 3456A from accepting locally generated trigger commands, although an HP-IB trigger is accepted. Refer to the Remote Operation paragraphs for additional information on the HP-IB trigger.

3-48. Autozero.

3-49. The Autozero feature of the -hp- Model 3456A is used to compensate offsets in the dc input amplifier circuit of the instrument. Its main purpose is to correct for any zero drift in circuitry which may cause errors. The method used is to short the amplifier's input to circuit ground and take its offset reading. The reading is then stored in the instrument's internal memory and is later used to correct the following input measurement(s). Once the offset reading is taken, the short is removed and a regular input measurement is taken. As long as the Autozero feature is enabled, the 3456A takes an Autozero measurement and an input measurement. When the feature is disabled, an Autozero measurement is taken and is immediately stored into memory. No new Autozero measurements are made for the successive readings; only an input measurement is made. The stored Autozero reading is subtracted from the input measurement to correct the reading. Since only the input measurement is made, the 3456A's reading rate increases. This also makes the instrument more suitable for making measurements on high impedance circuitry, since no input switching is done. The 3456A's long term stability is affected (see Table 1-1) with the disabled feature, unless the Autozero reading is updated. Updating is done when any change in instrument state occurs. The only exception is that no updating is done by triggering, Front Panel SRQ, and HP-IB Local commands. The Autozero feature is enabled when the 3456A is first turned on and when pressing the RESET button.

3-50. Autozero Effects on 4-Wire Ohms Measurement.

3-51. The Autozero measurement is normally made with the input amplifier shorted to circuit ground. In the 4-Wire Ohms mode, the input amplifier is shorted to the 4-WRΩ SENSE Low terminal for the Autozero Measurement. With Autozero "ON", the Autozero reading is updated for each measurement cycle. With Autozero "OFF", the reading is not updated and causes an ohms measurement error if the measuring lead's impedance changes. To prevent this error, a new Autozero reading should be taken by changing or updating instrument state with the new measuring lead configuration. A disabled Autozero is useful in ohms measurements for a faster reading rate and where the 3456A's input switching may have affected the measurement.

3-52. Analog Filter.

3-53. The 3456A's Analog Filter is a 3 pole active filter with greater than 60 dB attenuation at frequencies of 50

Hz and higher. The filter is normally applied between the instrument's input terminals and input amplifier. An exception is when the 3456A is in the ACV or ACV + DCV unshifted or shifted functions. The filter is then applied between the output of the ac convertor and the input amplifier. In these modes, select the filter for accurate measurements below 400 Hz. Refer to Table 1-1 for the ACV and ACV/DCV accuracy specifications with the filter in or out. The Analog Filter is enabled (or disabled) by pressing the FILTER button.

3-54. NUMBERED KEYBOARD OPERATIONS.

3-55. Refer to Figure 3-8 for the 3456A's Numbered Keyboard selectable operations.

3-56. Storing Into Registers.

3-57. The next paragraphs explain the Number of Power Line Cycles Integrated, Number of Readings per Trigger, Settling Delay, and a variety of math operations. Except for math, other operations are changed by storing numbers into appropriate registers. The math operations are selected by pressing the appropriate math key. Table 3-2 gives a short description of the registers and math operations.

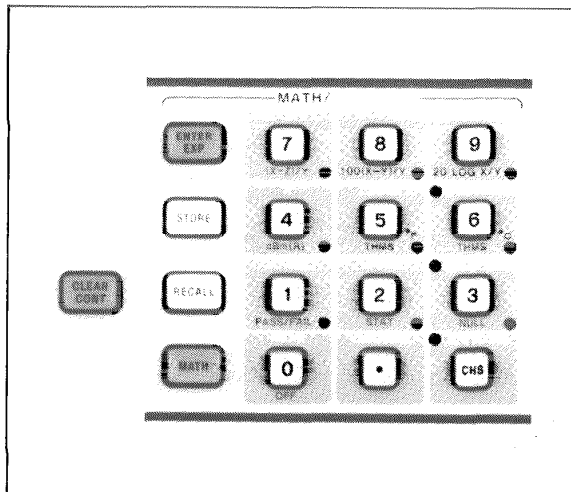


Figure 3-8. Front Panel Numbered Keyboard Area.

3-58. The Numbered Keyboard is very similar to those in pocket calculators with some keys performing more than two functions. Refer to the front panel. Note that the differences in key color, and the labeling above and below the keys determine the key's function. The blue color identifies the math operation, the white color identifies registers, and the black color identifies numbers, decimal point, and polarity. The white and blue color buttons located to the keyboard's left corresponds to the math and register operations.

3-59. Various LEDs on the keyboard annunciate which math function has been selected and which register contains a non-default number. For example, the LED next to the PASS/FAIL label lights if you select this math operation.

3-60. Storing numbers into registers:

a. Store. Numbers stored into registers changes the instrument's operation. For example, select the 100 Power Line Cycles Integrated mode (10 Line Cycles is the default value). To do this, "100" has to be stored into register N CYC INT. Try the following procedure.

1. Press the "1" key and the "0" key twice. These keys are on the Numbered Keyboard.
2. A "100" should now be displayed on the front panel.
3. Next press the white STORE button and then the CHS key (note, the white label above the CHS key is N CYC INT). The CHS key, which is normally the Change of Sign key, becomes the N CYC INT register key when the STORE button is pressed. (The CHS key is normally used to change the polarity of a number which is typed in from the keyboard, before storing into a register.)
4. The 3456A is now set to 100 Power Line Cycles Integrated. Use the same method to store numbers into the other registers.

Using this method you can select a six digit number (and a "1" as the overrange number) of any value and store it into a register. When a number is entered from the keyboard, the number is displayed before it is stored into a register. There is one important thing to remember when storing numbers. Some registers only accept certain numbers. The N DIG DISP (Number of Digits Displayed), for example, only accepts either a 3, 4, 5, or 6, since these are the only number of digits the 3456A can display. If you try to store an illegal number, Error 4 will be displayed.

NOTE

Since only a six digit number and overrange number can be entered, any additional numbers will be ignored.

b. EXP (Exponential). There are two ways to store numbers into registers using the Numbered Keyboard, Fixed Point and Floating Point. One way is to enter a number digit by digit and the other way is using the EXP (Exponential) key. A digit to digit entry looks like this: Enter "2", "0", "0", "0" to display "2000"

or

Enter "." "0", "2" to display ".02"

To enter the same numbers using the EXP key, first enter all of the number's significant digits and then press the ENTER EXP button. Once this is done, the displayed number is then stored into the desired register. The exponent can also be changed from a "+" to a "-" by pressing the CHS key. This is done before or after you enter the exponent and after pressing the ENTER EXP key. To enter "2000", do this:

Enter "2", press ENTER EXP key, and enter "3" displaying "2 + 3". The same as "2000"

To enter the number ".02" do this:

Enter "2", press the ENTER EXP button, enter "2", and press the CHS key displaying "2 - 2". The same as ".02"

Table 3-2. Registers and Math Listing.

Key	Register	Registers Default Values	Description
CHS	N CYC INT	10	Used for changing and determining the Number of Power Line Cycles Integrated
.	VARIANCE	.00 000-3	Used for storing the variance value determined from Statistics Math Operation
0	MEAN	199999 + 9	Used for storing the Mean Value determined from the Statistics Math operation.
1	LOWER	-1999999 + 9	Used for storing the lower value for the Pass/Fail Math operation or the lowest reading taken in the Statistics Math operation.
2	UPPER	1999999 + 9	Used for storing the upper value for the Pass/Fail Math operation or the highest reading taken in the Statistics Math operation.
3	DELAY SEC	0	Used for changing and determining the 3456A's Settling Delay.
4	R	600	Used for storing the resistor value for the dBm Math operation or for recalling readings taken in the 3456A's Reading Storage mode.
5	COUNT	0	Used for storing the number of readings taken while in the Statistics Math operation.
1	N RD/TRIG	1	Used for changing and determining the Number of Readings taken or are to be taken per Trigger.
7	Z	0	Used for storing a number value for the Scale Math operation and stores the first statistics Reading
1	Y	1	Used for storing a number value for the Scale and %Error Math operation.
9	N DIG DISP	5	Used for changing and determining the 3456A's Number of Digits Displayed.
Math			
CHS	-		
.	-		
0	OFF		Disables Math operation.
1	PASS/FAIL		Used to determine if a reading(s) is within set limits.
2	STATS		Used to calculate the Mean, Variance, Upper, Lower, and Count of a reading(s).
3	NULL		Used for offset compensation of the following reading(s) taken.
4	DBM		dBm calculation.
5	THMS F		Used in calculating a Thermistor reading(s) in degrees Fahrenheit.
6	THMS C		Used in calculating a Thermistor reading in degrees Celsius.
7	(X-Y)/Y		Used for the Scale calculation.
8	100 (X-Y)/Y		Used for the %Error calculation.
9	20 LOG X/Y		Used for the dB calculation.

NOTE

Pressing the EXP key before entering a number will display 1 + 0.

c. Recall. Any of the Registers can be recalled at any time. By pressing the RECALL button and the key for the Register to be displayed. (Remember, the registers are in white.) The Register's value is then displayed on the front panel.

d. Clear-Continue. The CLEAR-CONTINUE button, when pressed, clears the display and continues with the previous operation. This can be useful when accidentally entering an incorrect number from the keyboard. The Clear-Continue feature clears the incorrect number and starts a new measurement cycle. This feature can also be used when a register is recalled and no changes in the register are desired.

3-61. Number of Power Line Cycles Integrated.

3-62. This feature of the -hp- Model 3456A allows you to select the integration time from .01 to 100 power line cycles in multiples of 10. Since a power line cycle of "1" has a time period of 1/60 second, 1/50 for the 50 Hz option, the intergration time is 1/60 or 1/50 second. The Number of Power Line Cycles Integrated determines measurement time. The slowest integration time of the 3456A is 100 Power Line Cycles Integrated and the fastest is .01 line cycles. For good power line frequency noise rejection (Normal Mode Rejection), use integration times of either 1, 10, or 100 power line cycles. Use the Store method in Paragraph 3-60 to select the various integration times (Number of Power Line Cycles). The default value of the Number of Power Line Cycles Integrated is 10 (at Turn-on and Reset).

3-63. Digits Displayed.

3-64. The 3456A can display either a 3, 4, 5, or 6 digit reading. Select any of these digits using the Store method in Paragraph 3-60. The Number of Power Line Cycles Integrated determines the maximum number of digits the 3456A can display. If the 1 to 100 Power Line Cycles Integrated are used, the 3456A can display from 3 to 6 digits. With .01 Integration Time the maximum number of digits then is 4 and with .1 Line Cycles Integrated the maximum is 5. Five is also the number of digits displayed at Turn-On or when the RESET button is pressed.

3-65. Number of Readings per Trigger.

3-66. The Model 3456A is capable of taking from 1 to 9999 Readings per Trigger. Selection of the Number of Readings per Trigger is accomplished by using the Store method in Paragraph 3-60. The selected number of readings are executed each time the instrument is triggered. Although the Internal, External, and Single Trigger modes will take the selected number of readings, it

may be advantageous to use the External or Single Trigger modes. Using these modes, if a Single Trigger is sent the 3456A starts taking the readings and stops when all the readings are taken. Another trigger repeats the same operation. An Internal Trigger also does the same thing, but automatically triggers again when all readings are taken. The default value of the Number of Readings per Trigger at Turn-On or at Reset is "1".

3-67. Settling Delay.

3-68. This feature of the -hp- Model 3456A can be used to delay the 3456A's input measurement for a preselected time, before a measurement cycle (A/D operation) is started. The amount of Settling Delay is selected by using the Store method in Paragraph 3-60. In some modes (ACV, OHMS, and Analog Filter), a delay value is selected by the instrument. These selected delays are defined in Table 3-3 and can be changed to another value by using the Store method. Any number value from .001 second to 999.999 seconds (including 0) can be chosen for a delay in any mode. To return a 3456A selected delay to its default value store any negative number into the DELAY register.

Table 3-3. Default Delays.

3456A Set-Up Condition	Delay (in second)
DCV, Filter On	.650
ACV or ACV + DCV, Filter Off	.060
ACV or ACV + DCV, Filter On	.800
Ohms, 100 K Range	.001
Ohms, 1 M Range	.008
Ohms, 10 M Range	.080
Ohms, 100 M Range	.080
Ohms, 1 G Range	.080

3-69. Optimizing the Reading Rate.

3-70. The previous paragraph stated that the Number of Power Line Cycles Integrated has an effect on the Number of Digits displayed. In addition to that, the measurement accuracy and power line frequency noise rejection (NMR) are also affected. You can select a faster reading rate with a low Number of Power Line Cycles Integrated. But keep in mind that the 3456A's measurement error increases and that the ability to reject power line frequency noise rejection is lessened. Table 3-4 gives some ideas on how to optimize the 3456A's reading rate.

3-71. MATH FEATURE.

3-72. A variety of math operations can be done by the Model 3456A. Use the instrument's Numbered Keyboard to select a math operation and to enter values into registers used by the math operations. Refer to the Numbered Keyboard for the following discussion and make sure you know how to store values into registers

Table 3-4. Optimizing Reading Rate.**OPTIMIZING YOUR READING RATE**

Your maximum reading rate with the 3456A is influenced by a large number of factors, not the least of which is the signal you are trying to measure. These factors can be divided into two categories; signal related and voltmeter related. Among signal related factors are:

- desired accuracy (or resolution)
- nature of the signal (dcv, acv, or ohms)
- signal environment (line related and broadband noise)

Among voltmeter related factors are:

- method of measurement transfer (Packed Output, Reading Storage, System Output)
- number of convenience features selected (Math operations, Autorange)

For all operations, an equally important consideration is what you're trying to accomplish by measuring fast. Are you

- scanning a large number of points so that faster readings mean a better picture of what is happening at a single point in time?
- trying to read fast so that you do not use up valuable computer time waiting for the measurement operation to complete?
- trying to digitize waveforms?

The 3456A can solve these application problems in many different ways.

AT TURN-ON

For most bench and system applications, the preprogrammed settling times assure accurate readings regardless of the signal and signal environment. However, knowledge about your signal and/or signal environment can let you achieve up to 330 rds/s (at 60 Hz) with noise rejection and 10 microvolt sensitivity.

YOUR SIGNAL ENVIRONMENT

Your signal is subject to line related and broadband noise which can interfere with the measurement. There are two ways of rejecting noise on the 3456A; integration and input filtering.

Integration is a process where the affect of line related noise is averaged to zero over the period of an integer number of Power Line Cycles (PLC) during the A to D conversion. The basic integrator is an Op Amp with a (integrator) capacitor in its feedback loop. The signal is connected to the input of the Op Amp for a period of the line frequency. This configuration theoretically provides infinite noise rejection at integer multiples of the inverse of the integration period and single pole roll-off (20 dB of amplitude attenuation for every decade increase in frequency above the knee frequency) for broadband noise. Refer to the graph for more detail.

The input filter provides excellent noise rejection. The price you pay is an additional 650 ms settling time which allows the filter output to settle to a final value before the input is measured. The fastest possible reading rate measuring widely varying signals with line rejection is provided by 1 PLC integration time. But, if you are looking at a slowly varying signal or scanning similar signals, you can get faster readings by overriding the preprogrammed settling

time selecting 0.01 or 0.1 PLC integration time and the filter. The trade-off is less accuracy and resolution as well as more uncertainty about the filtered input.

SPEEDING THE MEASUREMENT CYCLE

The thermal stability of the measurement environment is important. By simply keeping the temperature of the 3456A at a fixed value, you can nearly double the reading rate by turning Auto Zero off. The 3456A is slightly less accurate but the faster reading rate may be worth it. In addition, any range, function, or filter change that takes place is automatically accompanied by an Auto Zero update which removes any accumulated offsets. Of course, if the measurement environment is quiet enough to omit NMR then only the accuracy and resolution of your desired measurement are the factors and you can achieve up to 210 or 330 rds/s with .1 and .01 PLC respectively (60 Hz).

Further, you can speed the measurement cycle by selecting a fixed range instead of using the Autorange function. Even at 1 PLC integration time there is a 10% reduction of the reading rate with Autorange on. Of course, if your signal is changing, Autorange is far faster than letting your software range the 3456A over the HP-IB.

AC Volts requires some special attention. With the filter off, you can measure signals of greater than 400 Hz frequency at a rate of 12 rds/s with the preprogrammed settling time of 60 ms. If you are monitoring a slowly changing ac signal or scanning similar signals, you can minimize the settling time to achieve up to 330 rds/s. Keep in mind that the input could change drastically before your readings would indicate a large change.

For signals of less than 400 Hz the input filter is connected in series with the ac converter to slow the signal response to the A to D converter. Again, you can override the preprogrammed settling time of 800 ms but beware! Large changes in the input signal level may let you read numerous wrong readings while the ac converter and the input filter are settling to a final value.

The 3456A can read resistance measurements as fast as dc volts up to the 10 K ohm range, but you can not use the input filter. Above the 10 K ohm range, additional settling time is required for stable resistance measurements. If all you want is an indication of the actual resistance above 10 K ohm, you can override the preprogrammed settling times. However, just considering the size of the resistance you are trying to measure and any associated stray capacitance in the measuring circuit, you may want to add settling time between reading for best accuracy.

Offset Compensated Ohms is very slow (10 rds/s) by comparison with a standard ohms measurement. But, for a single input reading, it is the fastest way to measure low value resistances accurately in the presence of thermally generated voltage offsets.

Before leaving the topic of Speeding the Measurement Cycle, it is important to ask why you would use 100 or 10 PLC integration times. The answer is increased accuracy and reduced internal noise. If you really need all the accuracy and repeatability you can get, the 100 PLC is the place you want to be.

SPEEDING THE READING TRANSFER

You might make many accuracy compromises to attain an acceptable reading rate and still not be able to read as fast