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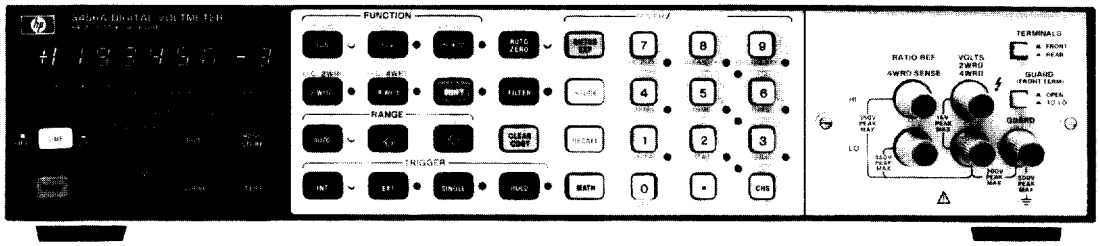
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# VOLTMETERS, DIGITAL & ANALOG

## 3½ to 6½ Digit DVM for Bench/System Applications

**Model 3456A**

- Up to 330 rdgs/s.
- 100 nanovolt resolution
- Transfer standard performance
- 100 micro-ohm to 1.0 gigaohm measurement capability
- Offset compensated ohms (OC Ω)
- Fast ac



HP 3456A

DESIGNED FOR HP-IB SYSTEMS

## Description

This microprocessor-based, fully guarded, integrating Digital Multimeter is designed for bench or systems. The HP Model 3456A measures dc, true RMS ac voltage and resistance.

Five full scale dc ranges from 0.1 volt to 1000 volts are provided. Measurement speed and accuracy can be enhanced for a specific application, using the HP 3456A's selectable integration time (up to 100 power line cycles) and settling time. An operator can select up to 330 readings/second for high speed bursts or one reading every fifteen minutes for periodic measurements. Resolution of 100 nanovolts at 48 readings/second (6½ digits) to 10 microvolt resolution at 330 readings per second (3½ or 4½ digits) can be selected.

Because the HP 3456A uses an integration technique with features such as "Program Memory" and "Reading Store", the operator can obtain the fastest possible reading rate with the most noise rejection. The first reading is correct, every time. The HP 3456A built-in memory is divided into two parts (Program and Reading Store). This feature lets the operator choose the length of program and the number of readings to be stored. For example, one could store an instrument command string 8 bytes long in program memory with room for 348 stored readings. The size of the HP 3456A memory is 1400 bytes long.

Transfer standard performance is assured with the HP 3456A. With good repeatability and 100 nanovolt sensitivity, accuracy on the ten volt range is ±0.0008% +2 counts over a 24-hour period at 23°C ±1 °C.

Four full-scale, true TRMS ac voltage ranges are provided, with reading speeds up to 12 per second speed over a 20 Hz to 250 kHz frequency range with 1 microvolt resolution (6 digits). Best accuracy is 0.05%. Crest factor is greater than seven at full scale.

### Offset Compensated Ohms

A technique called Offset Compensated Ohms is incorporated in the HP 3456A. The DMM compensates for any resistance inaccuracies that may be caused from thermally produced offset voltages in the circuit under test. In the ohms function, the instrument first measures the voltage drop across the circuit under test. The voltage measured is stored in the DMM. Simultaneously, the DMM supplies a fixed current through the circuit under test and measures the voltage drop. Since the thermal error first stored in in the DMM's memory, it is automatically eliminated from the measurement.

The measurement range is from 1 mΩ to 1.2 GΩ, using either 2 or 4 wire connections.

### System DMM

Standard on the HP 3456A is an isolated HP-IB (IEEE-488) I/O for systems operation. The front panel indicators on the HP 3456A display range, function and HP-IB status during remote operation. Also on the front panel is a SRQ (Service Request) button which can be used to flag or interrupt a computer. With the HP 3456A's program memory and reading storage capability, system programmers and operators can use only one desktop or minicomputer to control numerous test stations, each containing a HP 3456A. By depressing the HP 3456A numerical entry keys and SRQ, the computer can be instructed to transfer a measurement sequence to the HP 3456A. The HP 3456A can take measurements and store them while a computer continues its operation as before the SRQ interrupt.

Another system feature of the HP 3456A is its hardware scanner advance capability for scanned or multiplexed system applications. As soon as the HP 3456A's measurement cycle is complete, a TTL signal is available to trigger an HP 3495A Scanner or HP 3497A Data Acquisition/Control Unit to advance to their next channel. Up to 330 channels can be scanned per second without computer interaction.

### Bench DMM

With a 2 ppm stability, the HP 3456A is a true transfer standard offering either 100 nanovolt sensitivity or 0.001% accuracy. Other standard features include fast autorange and easy-to-use math functions. The user can scale, limit test, null and make measurements in percent error, dB and dBm, as well as themistor compensation in degrees F and C. A statistics function key (STAT) enables the operator to improve the HP 3456A's sensitivity, resolution and accuracy by averaging. Averaging reduces random noise fluctuations and improves sensitivity by a factor of the square root of the number of measurements. For example, for low level signals after 100 measurements, the actual sensitivity of the HP 3456A is approximately 10 nanovolts instead of 100 nanovolts. In addition, STAT enables the operator to recall the maximum (upper), minimum (lower), and variance.

Calibration of the HP 3456A is fast and convenient since all routine adjustments are accessible from a concealed door in the front panel. Should service be necessary, built-in diagnostics and PC Board modules make the HP 3456A easy to service.

## Specifications

### DC Voltage

#### Input Characteristics

| RANGE | MAXIMUM READING ($5^1/_2$ digit) | RESOLUTION $6^1/_2$ digit | RESOLUTION $5^1/_2$ digit | RESOLUTION $4^1/_2$ digit | INPUT RESISTANCE | MAXIMUM INPUT VOLTAGE |
|---|---|---|---|---|---|---|
| 0.1 V | .119999 V | 100 nV | 1 μV | 10 μV | $>10^{10}$ Ω | ±1000 V peak |
| 1.0 V | 1.19999 V | 1 μV | 10 μV | 100 μV | $>10^{10}$ Ω | |
| 10.0 V | 11.9999 V | 10 μV | 100 μV | 1 mV | $>10^{10}$ Ω | |
| 100.0 V | 119.999 V | 100 μV | 1 mV | 10 mV | 10 MΩ ±.5% | |
| 1000.0 V | 1000.00 V | 1 mV | 10 mV | 100 mV | 10 MΩ ±.5% | |

**Guard to chassis:** ±500 V peak
**Guard to low:** ±200 V peak

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**Measurement accuracy:** ± (% of reading + number of counts). Auto-zero on and filter off.

| | 24 hour: 23°C ±1°C | | 90 days: 23°C ±5°C | |
|---|---|---|---|---|
| RANGE | 6½ digit (≥10 PLC) | 6½ digit (1 PLC) | 6½ digit (≥10 PLC) | 6½ digit (1 PLC) |
| 0.1 V | .0022 + 24 | 0.0024 + 32 | 0.0034 + 24 | 0.0035 + 32 |
| 1.0 V | 0.0009 + 4 | 0.0012 + 5 | 0.0024 + 4 | 0.0025 + 5 |
| 10.0 V | 0.0008 + 2 | 0.0011 + 3 | 0.0023 + 2 | 0.0024 + 3 |
| 100.0 V | 0.0011 + 3 | 0.0014 + 4 | 0.0026 + 3 | 0.0027 + 4 |
| 1000.0 V[1] | 0.0011 + 2 | 0.0013 + 3 | 0.0024 + 2 | 0.0025 + 3 |

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

**Temperature coefficient:** ± (% of reading + number of counts/°C)

**5½ Digit Display**

| RANGE | 0.1V | 1.0V | 10.0V | 100.0V | 1000.0V |
|---|---|---|---|---|---|
| Temp Coef. | 0.0002 +0.2 | 0.0002 +0.2 | .0002 +.002 | 0.0002 +0.02 | 0.0002 +0.02 |

For 6½ digits, multiply counts by 10. For 4½ digits, multiply counts by .1

**Auto-zero OFF:** (5½ digit). For a stable environment ±1°C, add 10 counts for 0.1 V range, 1 count for 1 V and 100 V ranges, and .1 count for 10 V and 1000 V ranges. For 6½ digits, multiply counts by 10. For 4½ digits, multiply counts for .1.
**Filter ON:** rejection is >60 dB at 50 Hz. Add 2 μV to uncertainty for .1 V, 1.0 V and 10 V range and 200 μV for 100 V and 1000 V range.
**Response Time**
**Filter OFF:** for preprogrammed settling times (0.0 seconds), error is <0.0005% of input voltage step.
**Filter ON:** for preprogrammed settling times (.65 seconds), error is <.01% of input voltage step.

**NOISE REJECTION (dB) (1 kΩ unbalance in Lo)**

| | AC[3] NMR | AC[3] ECMR | DC ECMR |
|---|---|---|---|
| .01 PLC or .1 PLC | 0 | 90 | 140 |
| ≥1 PLC | 60 | 150 | 140 |
| ≥1 PLC with filter | 120 | 160 | 140 |

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

## AC RMS Voltage (ac, ac + dc)
**Input Characteristics**

| RANGE | MAXIMUM READING (5½ digit) | RESOLUTION 6½ digit | RESOLUTION 5½ digit | RESOLUTION 4½ digit | INPUT IMPEDANCE | MAXIMUM INPUT VOLTAGE |
|---|---|---|---|---|---|---|
| 1.0 V | 1.19999 V | 1 μV | 10 μV | 100 μV | 1 MΩ ±.5% shunted by <90 pF | ±1000 V peak (700 V rms) $10^8$ VHZ |
| 10.0 V | 11.9999 V | 10 μV | 100 μV | 1 mV | | |
| 100.00 V | 119.999 V | 100 μV | 1 mV | 10 mV | | |
| 1000.0 V | 700.00 V | 1 mV | 10 mV | 100 mV | | |

**Measurement accuracy:** ±(% of reading + number of counts). Auto-zero on, >1% of scale, and dc component <10% of ac component.
**90 days: 23°C ± 5°C**

| | FREQUENCY IN Hz | | | | |
|---|---|---|---|---|---|
| Filter OFF / Filter ON | 10 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 |
| 6½ digit (≥1 PLC)[2] | .47 + 450 | .07 + 730 | .17 + 1700 | .55 + 2900 | 5.0 + 6500 |
| 5½ digit (.1 PLC) | .48 + 90 | .08 + 73 | .18 + 173 | .56 + 293 | 5.0 + 653 |
| 4½ digit (.01 PLC) | .56 + 10 | .13 + 9 | .23 + 9 | .61 + 31 | 5.1 + 67 |

[1]Frequencies >100 kHz are specified for 1.0 V and 10 V ranges only.
[2]Integration Time in Power Line Cycles (PLC). For 5½ digits, multiply counts by 0.1. For 4½ digits, multiply counts by 0.01.

**Guard to chassis:** ±500 V peak
**Guard to low:** ±200 V peak
**Temperature coefficient:** ±(% of reading + number of counts)/°C. (5½ digit) ±(.008 + 6)/°C for DC component <10% ac component. Otherwise add ±(.008 + 12)/°C. For 6½ digit, multiply counts by 10. For 4½ digit, multiply counts by .1.
**DC component >10% of ac component:** (5¼ digit) Add ±(.5% of Reading + 50 counts) to accuracy. For 6½ digit, multiply counts by 10. For 4½ digit, multiply counts by .1. For signals with no ac component, use the 1 kHz ac spec.
**Crest factor:** >7:1 at full scale.
**Common mode rejection (1 kΩ Lo unbalance):** >90dB dc to 60 Hz.
**Auto-zero OFF:** for stable environment ±1°C no accuracy change.
**Response time:** for preprogrammed settling times, error is <.1% of input voltage step.
**Filter OFF:** 0.06 seconds
**Filter ON:** .80 seconds

## Resistance (2 WΩ, 4 WΩ, 2 WOCΩ, 4 WOCΩ)
**Input Characteristics**

| RANGE | MAXIMUM READING (5½ digit) | RESOLUTION 6½ digit | RESOLUTION 5½ digit | RESOLUTION 4½ digit | CURRENT THROUGH UNKNOWN | MAXIMUM VALID READING VOLTAGE | MAXIMUM OPEN CIRCUIT VOLTAGE |
|---|---|---|---|---|---|---|---|
| 100 Ω | 119.999 Ω | 100 μΩ | 1 mΩ | 10 mΩ | 1 mA | .12 V | 5.5 V |
| 1 kΩ | 1199.99 Ω | 1 mΩ | 10 mΩ | 100 mΩ | 1 mA | 1.2 V | 5.5 V |
| 10 kΩ | 11.9999 kΩ | 10 mΩ | 100 mΩ | 1 Ω | 100 μA | 1.2 V | 5.5 V |
| 100 kΩ | 119.999 kΩ | 100 mΩ | 1 Ω | 10 Ω | 50 μA | 6 V | 9.5 V |
| 1 MΩ | 1199.99 kΩ | 1 Ω | 10 Ω | 100 Ω | 5 μA | 6 V | 9.5 V |
| 10 MΩ | 11.9999 MΩ | 10 Ω | 100 Ω | 1 kΩ | 500 nA | 6 V | 9.5 V |
| 100 MΩ | 119.999 MΩ | 100 Ω | 1 kΩ | 10 kΩ | ≤500 nA[1] | 5 V | 5.5 V |
| 1 GΩ | 1000.00 MΩ | 1 kΩ | 10 kΩ | 100 kΩ | ≤500 nA[1] | 5 V | 5.5 V |

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

**Non-destructive overload:** 350 V peak
**Measurement accuracy:** ± (% of reading + number of counts). Auto-zero on, filter off, and 4-wire ohms.

| | 24 hour: 23°C ±1°C | | 90 days: 23°C ±5°C | |
|---|---|---|---|---|
| RANGE | 6½ digit (≥10 PLC) | 6½ digit (1 PLC) | 6½ digit (≥10 PLC) | 6½ digit (1 PLC) |
| 100 Ω | 0.003 + 24 | 0.003 + 32 | 0.004 + 24 | 0.004 + 32 |
| 1 kΩ | 0.002 + 4 | 0.003 + 5 | 0.003 + 4 | 0.004 + 5 |
| 10 kΩ | 0.002 + 4 | 0.003 + 5 | 0.003 + 4 | 0.004 + 5 |
| 100 kΩ | 0.002 + 2 | 0.003 + 3 | 0.003 + 2 | 0.004 + 3 |
| 1 MΩ | 0.006 + 2 | 0.006 + 3 | 0.007 + 2 | 0.007 + 3 |
| 10 MΩ | 0.041 + 2 | 0.041 + 3 | 0.042 + 2 | 0.042 + 3 |
| 100 MΩ | 1.3 + 1 | 1.3 + 1 | 1.8 + 1 | 1.8 + 1 |
| 1 GΩ | 11 + 1 | 11 + 1 | 16 + 1 | 16 + 1 |

**2-Wire ohms accuracy:** Same as 4-wire ohms except add a maximum of .2 ohm offset.
**Auto-zero OFF accuracy:** (5½ digit). For a stable environment ±1°C, add 10 counts for 100 Ω range, 1 count for 1 kΩ and 10 kΩ range, and .2 counts for ≥100 kΩ range. Changes in lead resistance are not corrected in 4-wire ohms. For 4½ digit, multiply counts by .1. For 6½ digit, multiply counts by 10.

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**Offset compensated ohms accuracy:** same as 2-wire and 4-wire except maximum reading may be reduced by 9% for large offset voltages.
**Response time:** with preprogrammed settling time and <200 pF of capacitance, first reading is in specification.
**Filter is not operational in ohms.**
**Temperature coefficient:** (5½ digits) ±(% of Reading + Number of Counts)/°C

| RANGE | 100 Ω | 1 kΩ 100 kΩ | 1 MΩ | 10 MΩ | 100 MΩ | 1 GΩ |
|---|---|---|---|---|---|---|
| Temp Coef. | .0004 +.2 | .0004 +.02 | .0004 +.004 | .0010 +.004 | .16 +0 | 1.6 −0 |

4½ digit: multiply counts by 0.1; 6½ digit: multiply counts by 10.

### 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, ac Volts, or ac + dc Volts
**Reference measurement:** automatically selects .1 V, 1 V, or 10 V dc. Volts range and a 0.0 ms. settling time. Filter is off.
**Maximum Reference Voltages**
Ref. Hi: ±12 V
Ref. Lo: ±9% of Ref. Hi
Ref. Hi-Ref. Lo: ±11.9999 V
Protection: ±340 V peak
**Accuracy:** total % signal error + total % reference error (same as .1 V, 1 V, or 10 V DC volts)

### 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 0.35 ms; ASCII output adds 2.3 ms per reading.
**Rates vs. integration time and auto-zero:** dc volts and 100 Ω thru 10 kΩ ranges with preprogrammed settling times (−0.0 s.). Also, ac or ac + dc volts and 100 kΩ thru 10 kΩ ranges with 0.0 s delay.

| INTEGRATION TIME IN POWER LINE CYCLES (PLC) | RATES(rdgs/second) Auto Zero OFF 60 Hz | Auto Zero OFF 50 Hz | Auto Zero ON 60 Hz | Auto Zero ON 50 Hz |
|---|---|---|---|---|
| 0.01 (4½ digit) | 330 | 290 | 210 | 180 |
| 0.10 (5½ digit) | 210 | 180 | 120 | 100 |
| 1.00 (6½ digit) | 48 | 40 | 25 | 20 |
| 10.00 (6½ digit) | 5.8 | 4.8 | 2.9 | 2.4 |
| 100.00 (6½ digit) | .57 | .47 | .29 | .24 |

### Memory
**Reading store:** can store up to 350 readings.
can be recalled from HP-IB interface or 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 is 1400 bytes. Memory used is 1 byte per ASCII character + 4 bytes per reading stored.

### Math Functions
**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 $0.000000 \times 10^{-9}$ to $\pm 1999999 + 10^{9}$. Out of range values send "OL" to display and $+1999999 \times 10^{9}$ 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 out-of-limit conditions.
**Maximum execution time:** 20 ms

**Statistics**

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

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

Maximum (U) and Minimum (L) are the most positive and negative instrument readings, respectively. X is displayed during calculation of statistics.
$X_1$ 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.
**Maximum execution time:** 50 ms
**Null:** $X - X_1$ ($X_1$ is the first valid reading taken after enabling null and is stored in the Z register).
**Maximum execution time:** 15 ms
**dBm(R):**

$$10 \log \left| \frac{x^2/R}{1\text{mW}} \right|$$ R is the user-entered impedance.

**Output range:** −280 to +340 dBm
**Maximum execution time:** 150 ms
**Thermistor (F):** converts resistance of thermistor HP0837-0164, YSI 44007, Omega UUA35J3, and Fenwal UUA35J1 to temperature in °F.
**Output range:** −112° to 302° F
**Maximum execution time:** 150 ms
**Scale:** (X − Z)/Y
**Maximum execution time:** 60 ms

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

**Output range:** −620 to +620 dB
**Maximum execution time:** 100 ms
**% Error:** 100 x (X−Y)/Y
**Maximum execution time:** 60 ms

## General
**Operating temperature:** 0 to 50°C
**Warmup time:** one hour to meet all specifications
**Humidity range:** 95% R.H., 0 to 40°C
**Storage temperature:** −40 to +75°C
**Power:** 100/120/240 V +5%, −10%, 48 Hz to 66 Hz line operation, 60 VA; 220 V ±10%, 48 Hz to 66 Hz line operation, 60 VA.
**Size:** 88.9 mm H x 425.5 mm W x 527.1 mm D (3½" x 16¾" x 20¾")
**Weight:** net, 10.49 kg (23.13 lb.); shipping, 13.35 kg (29.38 lb.)

| Ordering Information | Price |
|---|---|
| **HP 10833A:** 1 Meter (39.37 in.) HP-IB Cable | $80 |
| **HP 10833B:** 2 Meter (78.74 in.) HP-IB Cable | $90 |
| **HP 10833C:** 4 Meter (157.48 in.) HP-IB Cable | $100 |
| **HP 10833D:** 0.5 Meter (19.69 in.) HP-IB Cable | $80 |
| **03456-90001:** Operating information supplement (one furnished with HP 3456A) | |
| **HP 11002A:** Test Leads, dual banana to probe and alligator | $20 |
| **HP 34111A:** High Voltage Probe, 40 kV | $180 |
| **Opt 050:** Noise rejection for 50 Hz | N/C |
| **Opt 060:** Noise rejection for 60 Hz | N/C |
| **Opt 907:** Front handle kit, P/N 5061-0088 | +$50 |
| **Opt 908:** Rack flange kit, P/N 5061-0074 | +$30 |
| **Opt 909:** Rack flange and front handle kit, HP P/N 5061-0075 | +$72.50 |
| **Opt 910:** Extra operating & service manual | |
| **HP 3456A Digital Voltmeter** | **$3800** |

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