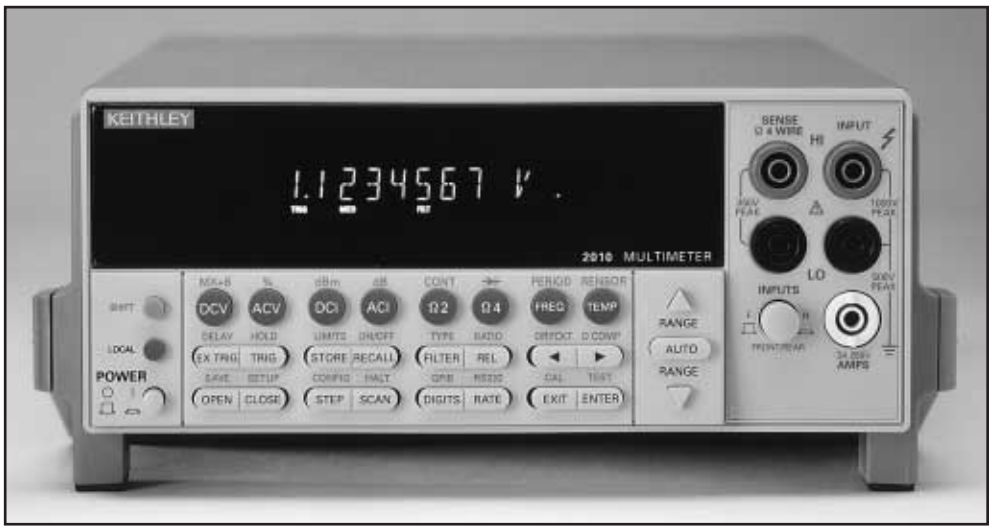
2010 Low-Noise Multimeter

- 7½-digit resolution
- 100nV rms noise floor
- 7ppm basic DCV accuracy
- Built-in 10-channel scanner mainframe
- Dry circuit and low power measurement mode
- 15 measurement functions including support for RTD and thermocouple temperature measurements
- Built-in ratio measurement function
- Easy to use, "no menus" front panel design



The 7½-digit Model 2010 Low Noise Multimeter combines high resolution with the high speed and accuracy needed for production applications such as testing sensors, transducers, A/D and D/A converters, regulators, references, connectors, switches, and relays. Based on the same high-speed, low-noise A/D converter technology as the Models 2000, 2001, and 2002, the 2010 is the latest addition to Keithley's Series 2000 line of high-performance Digital Multimeters.

The 2010 offers a variety of advantages when configuring production test systems:

- High DCV basic accuracy (7ppm), stability, and linearity (±2ppm of reading + 1ppm of range on the 10VDC range) to reduce total measurement uncertainty.
- Low noise floor (100nV) to allow more accurate millivolt- and microvolt-level measurements.
- A wide dynamic range, which minimizes range-shift errors and speeds systems applications by reducing range change delays.
- Built-in ratio measurement function for precise relative measurements and comparison testing.
- High throughput, with speeds up to 2000 readings/second (at 4½-digit resolution).

ORDERING INFORMATION

2010 Autoranging DMM

This product is available with an **Extended Warranty.** See page 635 for complete ordering information.

High Measurement Flexibility

The 2010 has 15 built-in measurement functions, including DCV, ACV, DCI, ACI, 2WΩ, 4WΩ, dry circuit resistance, temperature (with either thermocouples or RTDs), frequency, period, ratio, continuity measurement, and diode testing. This multi-functional design minimizes added equipment costs.

Creating a self-contained multipoint measurement solution is as simple as plugging a 2000-SCAN or 2001-TCSCAN scanner card into the option slot in the 2010's back panel. This "plug-in" approach eliminates the need for a separate scanner and significantly reduces programming and setup time in applications involving a limited number of test points. For larger applications, the 2010 is compatible with Keithley's 7000 Series switch matrices and cards.

Unique Resistance Measurement Functions

Characterizing the resistance, linearity, or isolation of contacts, connectors, switches or relays completely and efficiently demands an uncommon combination of ohms measurement capabilities. The 2010 offers:

- A low-power ohms measurement mode. Low-level resistance measurements can be made with source current as low as 100µA, an order of magnitude lower than is possible with other DMMs, so device self-heating is minimized. Among other benefits, this low-power measurement capability makes the 2010 suitable for end-of-life contact testing per ASTM B539-90.
- A dry circuit test function. When measuring contact and connector resistances, it is important to control the test voltage carefully in order to avoid puncturing any oxides or films that may have formed. A built-in clamp limits the open circuit test voltage to 20mV to ensure dry circuit conditions.
- Offset compensated ohms. This function eliminates thermal effects that can create errors in low-level resistance measurements in system environments.

QUESTIONS?
1-800-552-1115 (U.S. only)
Call toll free for technical assistance, product support or ordering information, or visit our website at **www.keithley.com**.

2010 Low-Noise Multimeter

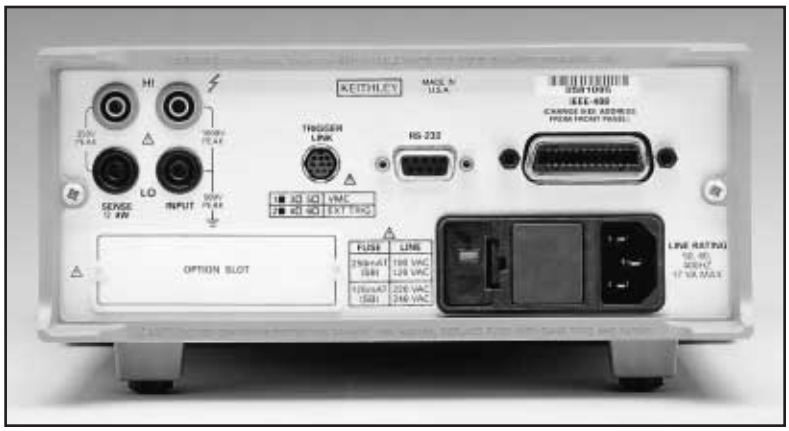
- An extended ohms measurement capability. The 2010 provides a 10Ω range for more precise measurements of low resistances.

Simple "No Menus" Design

The front panel of the 2010 was designed to allow users to begin making measurements almost immediately without the need to refer to the operator's manual constantly. Annunciators on the display screen make it easy to track which functions are enabled.

Applications

Applications for the 2010 Low-Noise Multimeter include millivolt and microvolt output testing, drift characterization, precision resistance measurement, contact resistance, linearity, isolation testing, and mixed measurements.



DC CHARACTERISTICS

CONDITIONS: MED (1 PLC)[1] or SLOW (5 PLC)

FUNCTION	RANGE	RESOLUTION	TEST CURRENT OR BURDEN VOLTAGE	INPUT RESISTANCE OR CLAMP VOLTAGE	ACCURACY: ±(ppm of reading + ppm of range) (ppm = parts per million) (e.g., 10ppm = 0.001%) 24 Hour[13] 23°C±1°	90 Day 23°C±5°	1 Year 23°C±5°	2 Years 23°C±5°	TEMPERATURE COEFFICIENT 0°–18°C & 28°–50°C
Voltage	100.00000 mV[17]	10 nV		> 10 GΩ	10 + 9	25 + 9	37 + 9	50 + 10	2 + 6
	1.0000000 V	100 nV		> 10 GΩ	7 + 2	18 + 2	25 + 2	32 + 2	2 + 1
	10.000000 V	1 µV		> 10 GΩ	7 + 4	18 + 4	24 + 4	32 + 4	2 + 1
	100.00000 V	10 µV		10 MΩ ±1%	10 + 4	25 + 5	35 + 5	52 + 5	5 + 1
	1000.0000 V[8]	100 µV		10 MΩ ±1%	17 + 6	31 + 6	41 + 6	55 + 6	5 + 1
Resistance[14]	10.000000 Ω	1 µΩ	10 mA		15 + 9	40 + 9	60 + 9	100 + 10	8 + 6
	100.00000 Ω	10 µΩ	1 mA		15 + 9	36 + 9	52 + 9	90 + 10	8 + 6
	1.0000000 kΩ	100 µΩ	1 mA		15 + 2	33 + 2	50 + 2	80 + 2	8 + 1
	10.000000 kΩ	1 mΩ	100 µA		15 + 2	32 + 2	50 + 2	80 + 2	8 + 1
	100.00000 kΩ	10 mΩ	10 µA		15 + 2	40 + 2	70 + 2	120 + 2	8 + 1
	1.0000000 MΩ	100 mΩ	10 µA		20 + 3	50 + 4	70 + 4	125 + 4	8 + 1
	10.000000 MΩ[10]	1 Ω	640 nA // 10MΩ		150 + 4	200 + 4	400 + 4	500 + 4	25 + 1
	100.00000 MΩ[10]	10 Ω	640 nA // 10MΩ		800 + 4	1500 + 4	1500 + 4	1800 + 4	150 + 1
Dry Circuit Resistance	10.00000 Ω[15]	10 µΩ	1 mA	20 mV	25 + 90	50 + 90	70 + 90	120 + 90	8 + 60
	100.0000 Ω	100 µΩ	100 µA	20 mV	25 + 90	50 + 90	70 + 90	120 + 90	8 + 60
Current	10.000000 mA	10 nA	< 0.15 V		60 + 15	300 + 40	500 + 40	740 + 40	50 + 5
	100.00000 mA	100 nA	< 0.18 V		100 + 15	300 + 40	500 + 40	740 + 40	50 + 5
	1.0000000 A	1 µA	< 0.35 V		200 + 15	500 + 40	800 + 40	1200 + 40	50 + 5
	3.000000 A	10 µA	< 1 V		1000 + 10	1200 + 15	1200 + 15	1800 + 15	50 + 5
Continuity 2W	1 kΩ	100 mΩ	1mA		40 + 100	100 + 100	120 + 100	190 + 10	8 + 1
Diode Test	10.000000 V	1 µV	1 mA		20 + 6	30 + 7	40 + 7	55 + 7	8 + 1
	4.400000 V	1 µV	100 µA		20 + 6	30 + 7	40 + 7	55 + 7	8 + 1
	10.000000 V	1 µV	10 µA		20 + 6	30 + 7	40 + 7	55 + 7	8 + 1
DCV:DCV Ratio[16]	100 mV to 1000 V				Ratio accuracy = accuracy of selected sense input range + accuracy of selected input range.				

DC OPERATING CHARACTERISTICS[3]

FUNCTION	DIGITS	READINGS/s		PLCs[7]
DCV (all ranges),	7½[2]	4	(3)	5
DCI (all ranges), and	6½[2,6]	30	(27)	1
Ohms (<10M range)	6½[2,4]	50	(44)	1
	5½[2,4]	260	(220)	0.1
	5½[4]	490	(440)	0.1
	5½[4]	1000	(1000)	0.04
	4½[4]	2000	(1800)	0.01

DC NOISE PERFORMANCE

RATE	DIGITS	RMS NOISE 100 MV RANGE 10 sec.	2 min.	RMS NOISE 10 V RANGE 10 sec.	2 min.	NMRR[11]	CMRR[12]
5 PLC	7½	100 nV	110 nV	1.1 µV	1.2 µV	60 dB	140 dB
1 PLC	6½	120 nV	125 nV	1.3 µV	1.4 µV	60 dB	140 dB
0.1 PLC	5½	1.5 µV	1.6 µV	11 µV	11.5 µV	—	80 dB
0.01 PLC	4½	3.0 µV	2.9 µV	135 µV	139 µV	—	80 dB

DC SYSTEM SPEEDS[3,5]

RANGE CHANGE[2]: 50/s (42/s).
FUNCTION CHANGE[2]: 45/s (38/s).
AUTORANGE TIME[2,9]: <30ms (<35ms).
ASCII READINGS TO RS-232 (19.2k baud): 55/s (55/s).
MAX. INTERNAL TRIGGER RATE: 2000/s (2000/s).
MAX. EXTERNAL TRIGGER RATE: 480/s (480/s).
RATIO SPEED[2,3]: 10/s (8/s).

2010 Low-Noise Multimeter

DC NOTES

1. For the following ranges, add 4ppm to the range accuracy specification: 100mV, 10Ω, 100Ω, 10mA, 100mA, and 1A. Dry circuit function add 40ppm.
2. Speeds include measurement and binary data transfer out the GPIB.
3. Speeds are for 60Hz (50Hz) operation using factory default operating conditions (*RST). Autorange off, Display off, Trigger delay = 0.
4. Sample count = 1024, auto zero off.
5. Auto zero off, NPLC = 0.01.
6. Ohms, 17 (15) readings/second.
7. 1 PLC = 16.67ms @ 60Hz, 20ms @ 50Hz/400Hz. The frequency is automatically determined at power up.
8. For signal levels >500V, add 0.02ppm/V uncertainty for the portion exceeding 500V.
9. Add 120ms for ohms.
10. Must have 10% matching of lead resistance in Input HI and LO.
11. For line frequency ±0.1%.
12. For 1kΩ unbalance in LO lead.
13. Relative to calibration accuracy.
14. Specifications are for 4-wire ohms or 2-wire ohms with REL function. 10Ω range is for 4-wire only.
15. Offset compensation on.
16. Sense LO input must be referenced to Input LO. Sense HI input must not exceed 125% (referenced to Input LO) of range selected. Sense input has 100mV, 1V and 10V ranges.
17. When properly zeroed using REL function.

DC GENERAL

LINEARITY OF 10VDC RANGE: ±(2ppm of reading + 1ppm of range).

DCV, Ω, TEMPERATURE, CONTINUITY, DIODE TEST INPUT PROTECTION: 1000V, all ranges.

MAXIMUM 4WΩ LEAD RESISTANCE: 5% of range per lead for 10Ω, 100Ω and 1kΩ ranges; 1kΩ per lead for all other ranges.

DC CURRENT INPUT PROTECTION: 3A, 250V fuse.

SHUNT RESISTOR: 0.1Ω for 3A and 1A ranges. 1Ω for 100mA range. 10Ω for 10mA range.

CONTINUITY THRESHOLD: Adjustable 1Ω to 1000Ω.

OVERRANGE: 120% of range except on 1000V, 3A and Diode.

OFFSET COMPENSATION: Available for 10kΩ and lower ranges only.

TRUE RMS AC VOLTAGE AND CURRENT CHARACTERISTICS

VOLTAGE RANGE	RESOLUTION	CALIBRATION CYCLE	ACCURACY [1]: ±(% of reading + % of range), 23°C ±5 °C 3Hz–10Hz	10Hz–20kHz	20kHz–50kHz	50kHz–100kHz	100kHz–300kHz
100.0000 mV	0.1 µV						
1.000000 V	1.0 µV	**90 Days**	0.35 + 0.03	0.05 + 0.03	0.11 + 0.05	0.60 + 0.08	4 + 0.5
10.00000 V	10 µV						
100.0000 V	100 µV	**1 Year**	0.35 + 0.03	0.06 + 0.03	0.12 + 0.05	0.60 + 0.08	4 + 0.5
750.000 V	1 mV						
		Temperature Coefficient [8]	0.035 + 0.003	0.005 + 0.003	0.006 + 0.005	0.01 + 0.006	0.03 + 0.0

CURRENT RANGE	RESOLUTION	CALIBRATION CYCLE	3Hz–10Hz	10Hz–5kHz
1.000000 A	1 µA	90 Day/1 Year	0.30 + 0.04	0.10 + 0.04
3.00000 A	10 µA	90 Day/1 Year	0.35 + 0.06	0.15 + 0.06
		Temperature Coefficient [8]	0.035 + 0.006	0.015 + 0.006

AC NOTES

1. Specifications are for SLOW rate and sine wave inputs >5% of range.
2. Speeds are for 60Hz (50Hz) operation using factory default operating conditions (*RST). Auto zero off, Auto range off, Display off, includes measurement and binary data transfer out the GPIB.
3. 0.01% of step settling error. Trigger delay = 400ms.
4. Trigger delay = 0.
5. DETector:BANDwidth 300, NPLC = 0.01.
6. Maximum useful limit with trigger delay = 175ms.
7. Applies to non-sinewaves >5Hz.
8. Applies to 0°–18°C and 28°–50°C.

ACCESSORIES AVAILABLE

COMPANION PRODUCTS

7001 or 7002	High Density Switch Systems

TEST LEADS

5804/5/6	4-Wire/Kelvin Test Lead Sets

SWITCH/SCANNER CARDS

2000-SCAN	10-channel Scanner
2001-TCSCAN	9-channel Thermocouple Scanner
7000 Series	Switch Cards for 7001 and 7002 Switch Systems

CABLES/ADAPTERS

7007-1	Shielded IEEE-488 Cable, 1m (3.3 ft)
7007-2	Shielded IEEE-488 Cable, 2m (6.6 ft)
8501-1	Trigger-Link Cables, 1m (3.3 ft),
8501-2	2m (6.6 ft)
8502	Trigger Link Adapter Box
8503	Trigger Link Cable to 2 male BNCs, 1m (3.3 ft)
7009-5	RS-232 Cable

RACK MOUNT KITS

4288-1	Single Fixed Rack Mount Kit
4288-2	Dual Fixed Rack Mount Kit

OTHER

KPCI-488	IEEE-488 Interface/Controller for the PCI Bus
KPC-488.2AT	IEEE-488 Interface Card for IBM PC/AT (full slot)
KPC-TM	Trigger Master Interface
TestPoint	Test Development Software
1050	Padded Carrying Case
2010-EW	1 Year Extended Warranty

See page 235 for descriptions of all accessories.

HIGH CREST FACTOR ADDITIONAL ERROR

±(% of reading) [7]

Crest Factor:	1–2	2–3	3–4	4–5
Additional Error:	0.05	0.15	0.30	0.40

AC OPERATING CHARACTERISTICS [2]

FUNCTION	DIGITS	RDGS./s	RATE	BANDWIDTH
ACV (all	6½ [3]	0.5 (0.4)	SLOW	3 Hz–300 kHz
ranges) and	6½ [3]	1.4 (1.5)	MED	30 Hz–300 kHz
ACI	6½ [4]	4.0 (4.3)	MED	30 Hz–300 kHz
	6½ [3]	2.2 (2.3)	FAST	300 Hz–300 kHz
	6½ [4]	35 (30)	FAST	300 Hz–300 kHz

AC SYSTEM SPEEDS [2, 5]

FUNCTION/RANGE CHANGE [6]: 4/s.

AUTORANGE TIME: <3s.

ASCII READINGS TO RS-232 (19.2K BAUD) [4]: 50/s.

MAX. INTERNAL TRIGGER RATE [4]: 300/s.

MAX. EXTERNAL TRIGGER RATE [4]: 300/s.

AC GENERAL

INPUT IMPEDANCE: 1MΩ ±2% paralleled by <100pF.

ACV INPUT PROTECTION: 1000V.

MAXIMUM DCV: 400V on any ACV range.

ACI INPUT PROTECTION: 3A, 250V fuse.

BURDEN VOLTAGE: **1A Range:** <0.35V rms. **3A Range:** <1V rms.

SHUNT RESISTOR: 0.1Ω on all ACI ranges.

AC CMRR: >70dB with 1kΩ in LO lead.

MAXIMUM CREST FACTOR: 5 at full scale.

VOLT HERTZ PRODUCT: $\leq 8 \times 10^7$ V·Hz.

OVERRANGE: 120% of range except on 750V and 3A ranges.

2010 Low-Noise Multimeter

FREQUENCY AND PERIOD CHARACTERISTICS [1,2]

ACV RANGE	FREQUENCY RANGE	PERIOD RANGE	GATE TIME	RESOLUTION ±(ppm of reading)	ACCURACY 90 Day/1 Year ±(% of reading)
100 mV	3 Hz	333 ms			
to	to	to	1 s	0.3	0.01
750 V	500 kHz	2 µs			

FREQUENCY NOTES

1. Specifications are for sine wave inputs >10% of ACV range, except 100mV range. On 100mV range frequency must be >10Hz if voltage is <20mV.
2. 20% overrange on all ranges except 750V range.

TEMPERATURE CHARACTERISTICS

THERMOCOUPLE [2,3,4] 90 DAY/1 YEAR (23°C ± 5°C)

TYPE	RANGE	RESOLUTION	ACCURACY [1] RELATIVE TO SIMULATED REFERENCE JUNCTION	ACCURACY [1] USING 2001-TCSCAN [5]
J	–200 to + 760°C	0.001°C	±0.5°C	±0.65°C
K	–200 to +1372°C	0.001°C	±0.5°C	±0.70°C
N	–200 to +1300°C	0.001°C	±0.5°C	±0.70°C
T	–200 to + 400°C	0.001°C	±0.5°C	±0.68°C

4-WIRE RTD [2,3,7,8]

RANGE	RESOLUTION	90 DAY/1 YEAR (23°C ± 5°C) ACCURACY [6]	2 YEAR (23°C ± 5°C) ACCURACY [6]
–100° to +100°C	0.001°C	±0.08°C	±0.12°C
–200° to +630°C	0.001°C	±0.14°C	±0.18°C

Temperature Notes

1. For temperatures <–100°C, add ±0.1°C and >900°C add ±0.3°C.
2. Temperature can be displayed in °C, K, or °F.
3. Accuracy based on ITS-90.
4. Exclusive of thermocouple error.
5. Specifications apply to channels 2–6. Add 0.06°C/channel from channel 6.
6. Excluding probe errors.
7. 100Ω platinum, D100, F100, PT385, PT-3916, or user type.
8. Maximum lead resistance (each lead) to achieve rated accuracy is 5Ω.

INTERNAL SCANNER SPEED

MAXIMUM INTERNAL SCANNER RATES: RANGE: CHANNELS/s [1]
TRIGGER DELAY = 0

DCV [2]	ACV [2,3]	2 WIRE OHMS [2]	4 WIRE OHMS [2]	T/C TEMPERATURE [2]	RTD TEMPERATURE [2]
All : 105	All : 96	All : 102	<10MΩ : 55	All : 70	All : 2

TRIGGER DELAY = AUTO

DCV [2]	ACV [2,3]	2 WIRE OHMS [2]	4 WIRE OHMS [2]	T/C TEMPERATURE [2]	RTD TEMPERATURE [2]
0.1 V : 100	All : 1.8	100 Ω : 82	100 Ω : 42	All : 70	All : 2
1 V : 100		1 kΩ : 85	1 kΩ : 42		
10 V : 100		10 kΩ : 42	10 kΩ : 25		
100 V : 70		100 kΩ : 28	100 kΩ : 21		
1000 V : 70		1 MΩ : 8	1 MΩ : 7		
		10 MΩ : 5	10 MΩ : 5		
		100 MΩ : 3	100 MΩ : 3		

Internal Scanner Speed Notes

1. Speeds are for 60Hz or 50Hz operation using factory default operating conditions (*RST). Auto Zero off, Auto Range off, Display off, sample count = 1024.
2. NPLC = 0.01.
3. DETector BANDwidth: 300.

Triggering and Memory

READING HOLD SENSITIVITY: 0.01%, 0.1%, 1%, or 10% of reading.
TRIGGER DELAY: 0 to 99 hrs (1ms step size).
EXTERNAL TRIGGER DELAY: <1ms.
EXTERNAL TRIGGER JITTER: <500µs.
MEMORY: 1024 readings.

Math Functions

Rel, Min/Max/Average/StdDev (of stored reading), dB, dBm, Limit Test, %, and mX+b with user defined units displayed.
dBm REFERENCE RESISTANCES: 1 to 9999Ω in 1Ω increments.

REMOTE INTERFACE

Keithley 199/196 Emulation
GPIB (IEEE-488.2) and RS-232C
SCPI (Standard Commands for Programmable Instruments)

GENERAL

POWER SUPPLY: 100V / 120V / 220V / 240V ±10%.
LINE FREQUENCY: 45Hz to 66Hz and 360Hz to 440Hz, automatically sensed at power-up.
POWER CONSUMPTION: 22VA.
OPERATING ENVIRONMENT: Specified for 0°C to 50°C. Specified to 80% R.H. at 35°C.
STORAGE ENVIRONMENT: –40°C to 70°C.
WARRANTY: 3 years.
SAFETY: Designed to IEC-1010-1.
EMC: Complies with European Union Directive 89/336/EEC (CE marking requirements), FCC part 15 class B, CTSPR 11, IEC 801-2, IEC 801-3, IEC 801-4.
VIBRATION: MIL-T-28800E Type III, Class 5.
WARMUP: 2 hours to rated accuracy.
DIMENSIONS:
Rack Mounting: 89mm high × 213mm wide × 370mm deep (3½ in × 8⅜ in × 14⁹⁄₁₆ in).
Bench Configuration (with handle and feet): 104mm high × 238mm wide × 370mm deep (4⅛ in × 9⅜ in × 14⁹⁄₁₆ in).
SHIPPING WEIGHT: 5kg (11 lbs).
VOLT HERTZ PRODUCT: ≤8 × 10⁷V·Hz.
ACCESSORIES SUPPLIED: Model 1751 Safety Test Leads, User Manual, Service Manual.