

# MODEL 160B

## DIGITAL MULTIMETER



- measures 1 microvolt to 1200 volts;  
10 picoamperes to 2 amperes;  
1 milliohm to 2000 megohms
- 1200-volt floating capability;
- $0.2\mu\text{V}/^\circ\text{C}$  stability
- battery option
- optional BCD digital output
- can be calculator controlled — see page 16



The Model 160B Digital Multimeter has the ranges, sensitivity, and performance that make it a key addition to any research or engineering laboratory. It is versatile enough for general use yet capable of outstanding performance in the most sophisticated applications.

High sensitivity of 1 microvolt per digit supported by stability of  $0.2$  microvolt per  $^\circ\text{C}$  results in an instrument capable of routinely handling many of the measurements which heretofore required specialized equipment. The wide-ranging current and resistance measuring capability of the 160B round out its performance versatility.

Advanced design and production techniques enable the 160B to be sophisticated enough to serve applications involving thermocouples, photomultiplier tubes, semiconductor materials, ion chambers, thermistors, bolometers, circuit analysis, troubleshooting, calibration, and many more.

Wide ranges, high sensitivity and excellent stability are a part of the 160B, but that's not all. Battery operation for portability and complete isolation from power lines are important. So the 160B has an optional rechargeable battery pack, and there's no degradation of specifications when it's used.

The input to a lab DMM should be able to float off ground — as high as possible. That's why the 160B is capable of floating as high as 1200 volts and even measuring 1200 volts on top of that!

Since DMMs in a lab are rarely pampered, the 160B is capable of taking punishing overloads. Up to 1200 volts on the voltage ranges and 250 volts of power line on the ohms ranges will not harm this DMM. Of course, that ruggedness must also apply to the construction of the instruments. So the 160B uses the same proven high-impact case and mechanical design of our general-purpose Model 168 (see page 6) — and that one is even used by construction crews.

Keithley's traditional analog output is also provided. The 160B has a 1-volt, 1-milliampere output for continuous recording, monitoring or controlling.

As a dc voltmeter the 160B provides ranges that cover virtually any measurement, from sensitive thermocouple signals to high-voltage power supplies. Full-scale displays from 1.999 millivolts to 1200 volts on seven ranges give the versatility needed in any laboratory. Accuracy on each of the 160B's voltage ranges is better than 0.1% of reading + 0.1% of range, making all the digits of the  $3\frac{1}{2}$  digit display meaningful and useable. The accuracy is supported by a high 10-megohm input impedance to minimize loading of sensitive circuits being measured.

Interfering signals and ground loops are handled by the Model 160B's excellent normal-mode ac rejection of up to 80 dB and outstanding common-mode rejection of 140 dB.

The Model 160B Digital Multimeter reads signals quickly too. Settling time (to within 0.1% of final reading) is less than 2 seconds except on the most sensitive range (1999 microvolts) where it is only 4 seconds.

As a dc ammeter the 160B reaches current sensitivities previously requiring electrometer picoammeters. Furthermore, it does it with an input voltage drop of only 10 millivolts at a 1000 count reading thus keeping ammeter-loading to a virtually negligible minimum. The DMM will measure currents from 10 pA/digit to 2 amperes. Basic accuracy is 0.2% of reading + 0.1% of range except on the extreme upper and lower ranges where an additional 0.1% uncertainty exists.

As an ohmmeter the DMM measures from 1 milliohm per digit (1.999  $\Omega$  full-display) up to a whopping 2000 megohms. The front-panel zero control is used for cancelling lead resistance on the sensitive ranges. Power dissipation is kept low since the voltage across the unknown resistance is 100 mV at full range on most ranges and decreases on the lower ranges. The maximum voltage that the 160B will develop into an open circuit is only 0.6 volts which enables many voltage-sensitive devices to be connected without need for concern over high open-circuit voltages on the DMM's input.

Additionally, there's a host of features and accessories to make the Model 160B even more useful. A durable tiltbail doubles as a carrying handle and the line cord neatly wraps around the bottom to make the unit easily portable, while a rack-mount kit makes it stay put. A hard-shell carrying case conveniently protects the instrument against mishandling when it is being transported. Other optional accessories include the Model 1601 AC/DC Probe, the Model 1682 RF Probe, Test lead options — Models 1681 and 1683, and the Model 1651 Current Shunt for current readings up to 50 amperes (see DMM ACCESSORIES, page 5).

The 160B has an optional digital output too. The 1602B Digital Output can be field installed with only a screwdriver and about two minutes' time. It features BCD presentation of the data, decimal location, and polarity. The output can be strobed in 4-bit multiples thus permitting serial interrogation by systems that cannot handle full output data in parallel format. That makes it convenient for systems or data collection applications.

Expand the performance of the Model 160B through the use of Keithley Scanners and Digital Printer (see page 18), or Calculator-based Systems (see page 16) for automatic data acquisition and control of your measurement.

AS A DC VOLTMETER

RANGE	MAXIMUM READING	ACCURACY ± (% of rdg + % of mg)		INPUT RESISTANCE	TEMPERATURE COEFFICIENT ± (% of rdg + % of mg)/°C		MAX. ALLOWABLE INPUT dc + peak ac
1 mV	1.999 mV	0.1%	0.1%	10 MΩ	0.01%	0.01%	600 V*
10 mV	19.99 mV	0.1%	0.1%	10 MΩ	0.01%	0.01%	600 V*
100 mV	199.9 mV	0.1%	0.1%	10 MΩ	0.01%	0.01%	600 V*
1 V	1.999 V	0.1%	0.1%	10 MΩ	0.01%	0.01%	1200 V
10 V	19.99 V	0.1%	0.1%	10 MΩ	0.01%	0.01%	1200 V
100 V	199.9 V	0.1%	0.1%	10 MΩ	0.01%	0.01%	1200 V
1000 V	1200 V	0.1%	0.1%	10 MΩ	0.01%	0.01%	1200 V

\*1200 V momentary.

**NORMAL MODE REJECTION RATIO:** Greater than 90 dB above one digit on the 1-millivolt and 10-millivolt ranges, and greater than 60 dB above one digit on the higher ranges, for voltages of line frequency or twice line frequency, with at least 1% of full range dc applied.

**ZERO STABILITY:** ±0.2 microvolts per °C.

**COMMON MODE REJECTION RATIO (1 k Ω unbalance):** Greater than 140 dB at dc and 40 to 200 Hz ac with at least 1% of full range dc applied. 1000 volts dc + peak-to-peak ac maximum.

**SETTLING TIME:** Less than 2 seconds to within 0.1% of final reading, except less than 4 seconds on the 1 mV range.

AS A DC AMMETER

RANGE	MAXIMUM READING	ACCURACY ± (% of rdg + % of mg)		SHUNT RESISTANCE	TEMPERATURE COEFFICIENT ± (% of rdg + % of mg)/°C		MAX. ALLOWABLE INPUT
10 nA	19.99 nA	0.3%	0.2%	1 MΩ	0.02%	0.02%	0.25 mA
100 nA	199.9 nA	0.2%	0.1%	100 kΩ	0.02%	0.01%	2.5 mA
1 μA	1.999 μA	0.2%	0.1%	10 kΩ	0.02%	0.01%	3 A*
10 μA	19.99 μA	0.2%	0.1%	1 kΩ	0.01%	0.01%	3 A*
100 μA	199.9 μA	0.2%	0.1%	100 Ω	0.01%	0.01%	3 A*
1 mA	1.999 mA	0.2%	0.1%	10 Ω	0.01%	0.01%	3 A*
10 mA	19.99 mA	0.2%	0.1%	1 Ω	0.01%	0.01%	3 A*
100 mA	199.9 mA	0.3%**	0.1%	0.1 Ω	0.01%	0.01%	3 A*
1000 mA	1999 mA	0.3%**	0.1%	0.1 Ω	0.01%	0.01%	3 A*

\*Internally fused beyond 3 amperes.

\*\*Self-heating due to long-term measurement of greater than 1 ampere can cause 0.1% additional error.

**NORMAL MODE REJECTION RATIO:** Greater than 60 dB above one digit for a current of line frequency or twice line frequency.

AS AN OHMMETER

RANGE	MAXIMUM READING	ACCURACY ± (% of rdg + % of mg)		VOLTAGE ACROSS UNKNOWN* at full range	TEMPERATURE COEFFICIENT ± (% of rdg + % of mg)/°C		MAX. ALLOWABLE INPUT rms ac+dc
1 Ω	1.999 Ω	0.4%	0.1%	1 mV	0.04%	0.03%	250 V
10 Ω	19.99 Ω	0.3%	0.1%	10 mV	0.04%	0.01%	250 V
100 Ω	199.9 Ω	0.3%	0.1%	100 mV	0.04%	0.01%	250 V
1 kΩ	1.999 kΩ	0.3%	0.1%	100 mV	0.04%	0.01%	250 V
10 kΩ	19.99 kΩ	0.3%	0.1%	100 mV	0.04%	0.01%	250 V
100 kΩ	199.9 kΩ	0.3%	0.1%	100 mV	0.04%	0.01%	250 V
1 MΩ	1.999 MΩ	0.3%	0.1%	100 mV	0.04%	0.01%	250 V
10 MΩ	19.99 MΩ	0.3%	0.1%	100 mV	0.04%	0.01%	250 V
100 MΩ	199.9 MΩ	10.0%	0.1%	100 mV	0.04%	0.01%	250 V
1000 MΩ	1999 MΩ	30.0%	0.1%	100 mV	1.0 %	0.01%	250 V

\*0.6 volt maximum into an open circuit.

GENERAL

**DISPLAY:** 3 digits plus 1 overrange digit; decimal position, polarity, and overload indication, 5 readings per second. 3 least significant digits blank when overload condition exists, except on 1000-volt range.

**ISOLATION:** Lo to power line ground greater than 1000 megohms shunted by less than 300 picofarads. Lo may be floated up to ±1200 volts with respect to power line ground.

**ANALOG OUTPUT:** ±1 volt dc at up to 1 milliampere for full range input, 100% overranging except on the 1000-volt range, where overranging is 20%.

**OFFSET CURRENT:** Less than 10 picoamperes.

**WARMUP:** 1/2 hour to complete stabilization.

**ENVIRONMENT:**

**Operating:** 10° to 35°C, 0% to 80% relative humidity. 0°C to 10°C and 35°C to 50°C, 0% to 80% relative humidity within twice computed accuracy.

**Storage:** -25°C to 70°C, without batteries installed.

**POWER:** 90-110, 105-125, 195-235 or 210-250 volts (switch selected). 50-60 Hz. 5 watts. Optional rechargeable 6-hour battery pack. (Model 1688A).

**CONNECTORS:** Input: binding posts. Analog Output: banana jacks.

**DIMENSIONS, WEIGHT:** Style K, 85 mm high x 235 mm wide x 275 mm deep (3 1/8 in. x 9 1/4 in. x 10 3/4 in.). Net weight, exclusive of batteries 1.8 kg (4 lbs.).

**ACCESSORIES AVAILABLE:** (See DMM ACCESSORIES, page 5.)

Model 1600 High Voltage Probe .....	\$ 75
Model 1601 AC/DC Probe .....	\$ 75
Model 1602B Digital Output* .....	\$ 195

ACCESSORIES AVAILABLE (continued)

Model 1609 Calibration Cover .....	\$ 18
Model 1010 Single Rack Mounting Kit (See page 63) .....	\$ 40
Model 1017 Dual Rack Mounting Kit (See page 63) .....	\$ 50
Model 1651 50-Ampere Shunt .....	\$ 20
Model 1681 Clip-on Test Lead Set .....	\$ 5
Model 1682 RF Probe .....	\$ 95
Model 1683 Universal Test Lead Kit .....	\$ 10
Model 1684 Hard Shell Carrying Case .....	\$ 38
Model 1688A Rechargeable Battery Pack* .....	\$ 75
Ni Cd rechargeable batteries give 6 hours operation from full charge — recharge in 1 1/2 hours per hour of discharge. Field installable with screwdriver. Adds 1 kg (2 lbs.), 4 watts (used on Models 160B and 168). Temperature Limits: -25°C to +45°C.	
Model 750 Printer with Model 7501-160B/1602B Printer Input Interface (e.g. +1.234) .....	\$ 1250
Note: *1602B and 1688A cannot be installed simultaneously	
<b>PRICES:</b> (For export pricing see inside front cover.)	
Model 160B Digital Multimeter (bench) .....	\$ 525
Model 160B/1602B Digital Multimeter with Digital Output Installed (bench) .....	\$ 720
Model 160B/1688A Digital Multimeter with Rechargeable Battery Pack Installed (bench) .....	\$ 600

**DIGITAL OUTPUT:**BCD open collector positive logic represents each of 3 digits, overrange digit, overload, decimal position, and polarity.

**FLAG (FLAG):**Present for approximately 200 milliseconds during each conversion. No change in Digital Output is made during this interval.

**OUTPUT LOGIC LEVELS:**

- Output logic "1" ≡ open collector to output LO.
- Output Logic "0" ≡ closure to output LO.
- Output Device: 2N5089 or equivalent (greater than 25-volt breakdown, less than 0.5 volt while sinking + 15 milliamperes).

**REMOTE CONTROLS:**

- Strobe:** 6 lines for serializing in multiples of 4 bits. Logic "1" inhibits controlled output lines.
- Output Hold:** Logic "0" retains data from last reading at Digital Output.
- Display Hold:** Logic "0" retains data from last reading (except for polarity and decimal) at Digital Output and Display.
- FLAG/FLAG Reset:** Transition from Logic "1" to logic "0" resets FLAG and FLAG for remainder of conversion in process.

**CONTROL LOGIC LEVELS:**

- Logic "1" ≡ either an open circuit or a voltage between +3.5 and + 15 volts referenced to output LO.
- Logic "0" ≡ closure to output LO within 0.8 volt while sinking +1 milliampere.

**PRINT RATE:**5 readings per second.

**ENVIRONMENT:** **Operating:** 0°C to 50°C, 0% to 80% relative humidity. **Storage:** -25°C to 70°C.

**CONNECTOR:**Output: AMP205209-1

**DIMENSIONS, WEIGHT:**Mounts inside 160B. Field installable with screwdriver. Adds 0.3 kg (0.5 lbs.) to 160B.

**POWER:** Obtained from 160B. Consumes negligible power.

**ACCESSORIES SUPPLIED:** Output mating connector and hood.

**PRICE:** (For export pricing see inside front cover.)

Model 1602B Digital Output Kit .....	\$ 195
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