Instruction Manual
Model 177 Microvolt DMM
and
Model 1788 Battery Pack

Cleveland, Ohio, U.S.A.
Document Number 29683

Specifications

DC VOLTAGE

RANGE	MAXIMUM READING	ACCURACY (12 mo.) 18°—28°C ±(% rdg + digits)	MAXIMUM ALLOWABLE INPUT
20mV*	19.999	0.04% + 2d	1200V momentary**
200V*	199.99	0.04% + 1d	1200V momentary**
2V	1.9999	0.03% + 1d	1200V momentary**
20V	19.999	0.03% + 1d	1200V
200V	199.99	0.03% + 1d	1200V
1200V	1200.0	0.035% + 1d	1200V

*Front panel zero

**Momentary=8/seconds/minute at 1200V, 450V continuous.

TEMPERATURE COEFFICIENT (0°—18°C and 28°—55°C): ±(0.005% + 0.1 digit)/°C except ±(0.005% + 0.6 digit)/°C on the 20mV range

INPUT RESISTANCE: 10MΩ ± 0.5%

NMRR: Greater than 80dB on the 20mV range at 50Hz and 60Hz; greater than 60dB on all other range

CMRR (1kΩ unbalance): Greater than 120dB at DC, 50Hz & 60Hz

AC VOLTAGE

RANGE	MAXIMUM READING	ACCURACY (12 mo.) (above 2000 counts) 18°-28°C; 100Hz-10kHz ±(% rdg + digits)
		0.5% + 15d
		0.5% + 15d
		0.5% + 15d
		0.5% + 15d
		0.5% + 15d

EXTENDED FREQUENCY ACCURACY (45Hz—20kHz): ±(0.7% + 15 digits)

TEMPERATURE COEFFICIENT (0°—18°C & 28°—55°C; 45Hz—20kHz): ±(0.05% + 2 digits)/°C

RESPONSE: True root mean square

CREST FACTOR: 3

INPUT IMPEDANCE: 1MΩ ±1% shunted by less than 75pF.

MAXIMUM ALLOWABLE INPUT VOLTAGE: 1000V rms, 1400V peak, 10^7•Hz maximum

CMRR (1kΩ unbalance): 60dB at DC, 50Hz and 60Hz

RESISTANCE

RANGE	MAXIMUM READING	ACCURACY (12 mo.) 18°—28°C ±(% rdg + digits)	TEMPERATURE COEFFICIENT 0°-18°C & 28°-55°C ±(% rdg + digits)/°C	NOMINAL APPLIED CURRENT
200Ω*	19.999	0.05% + 3d	0.004% + 0.6d	1mA
200Ω*	199.99	0.05% + 2d	0.004% + 0.2d	1mA
2kΩ	1.9999	0.04% + 1d	0.004% + 0.2d	1mA
20kΩ	19.999	0.04% + 1d	0.004% + 0.2d	100μA
200kΩ	199.99	0.04% + 1d	0.004% + 0.2d	10μA
2000kΩ	1999.9	0.04% + 1d	0.005% + 0.2d	1μA
20MΩ	19.999	0.10% + 1d	0.02% + 0.2d	0.1μA

*Front panel zero

MAXIMUM ALLOWABLE INPUT: 350V peak

OPEN-CIRCUIT VOLTAGE: 5 volts

DC & TRMS AC CURRENT

RANGE	MAXIMUM READING	ACCURACY (12 mo.) 18°—28°C ±(% rdg + digits) DC*	AC 45Hz—10kHz (above 2000 counts)	MAXIMUM VOLTAGE BURDEN
20μA	19.999	0.2% + 2d	—	0.02V
200μA	199.99	0.2% + 1d	0.8% + 15d	0.2V
2mA	1.9999	0.2% + 1d	0.8% + 15d	0.2V
20mA	19.999	0.2% + 1d	0.8% + 15d	0.2V
200mA	199.99	0.2% + 1d	0.8% + 15d	0.25V
2000mA	1999.9	0.2% + 1d	0.8% + 15d	0.6V

*Front panel zero

MAXIMUM INPUT: 2A, 250V DC or rms (fuse protected)

TEMPERATURE COEFFICIENT (0°—18°C and 28°—55°C):

DC: ±(0.2 digits)/°C except ±(0.01% + 0.6 digits)/°C on 20μA range.

AC: ±(0.07% + 2 digits)/°C

CREST FACTOR: 3

GENERAL

DISPLAY: Five 0.5" LED digits, appropriate decimal point and polarity indication

CONVERSION PERIOD: 400mS

OVERRANGE INDICATION: Display blinks all zeros above 19999 counts

MAXIMUM COMMON MODE VOLTAGE: 1400V peak

ANALOG OUTPUT: Output Voltage: 1V = 10,000 counts
Output Resistance: 5000Ω

ENVIRONMENT: Operating: 0°C to 55°c; 0% to 80% relative humidity up to 40°C.
Storage: −25°C to +65°C

CONNECTORS: Input: Binding posts
Output: Banana jacks

POWER: 105—125 or 210—250 volts (switch selected), 90—110V available. 50—60Hz, 8 watts. Optional 6 hour battery pack, Model 1788

DIMENSIONS WEIGHT: 85mm high × 235mm wide × 275mm deep (3½" × 9¼" × 10¾"). Net weight: 1.7kg (4 lb)

ACCESSORIES AVAILABLE:

Model 1010:	Single Rack Mounting Kit
Model 1017:	Dual Rack Mounting Kit
Model 1301:	Temperature Probe
Model 1600A:	High Voltage Probe (40kV)
Model 1641:	Kelvin Test Leads
Model 1651:	50-Ampere Current Shunt
Model 1681:	Clip-On Test Lead Set
Model 1682A:	RF Probe
Model 1683:	Universal Test Lead Kit
Model 1684:	Hard Shell Carrying Case
Model 1685:	Clamp-On AC Probe
Model 1691:	General Purpose Test Lead Set
Model 1779:	Spare Parts Kit
Model 1788:	Rechargeable Battery Pack
Model 1792:	Isolated BCD Output
Model 1793:	Isolated IEEE-488 Output

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

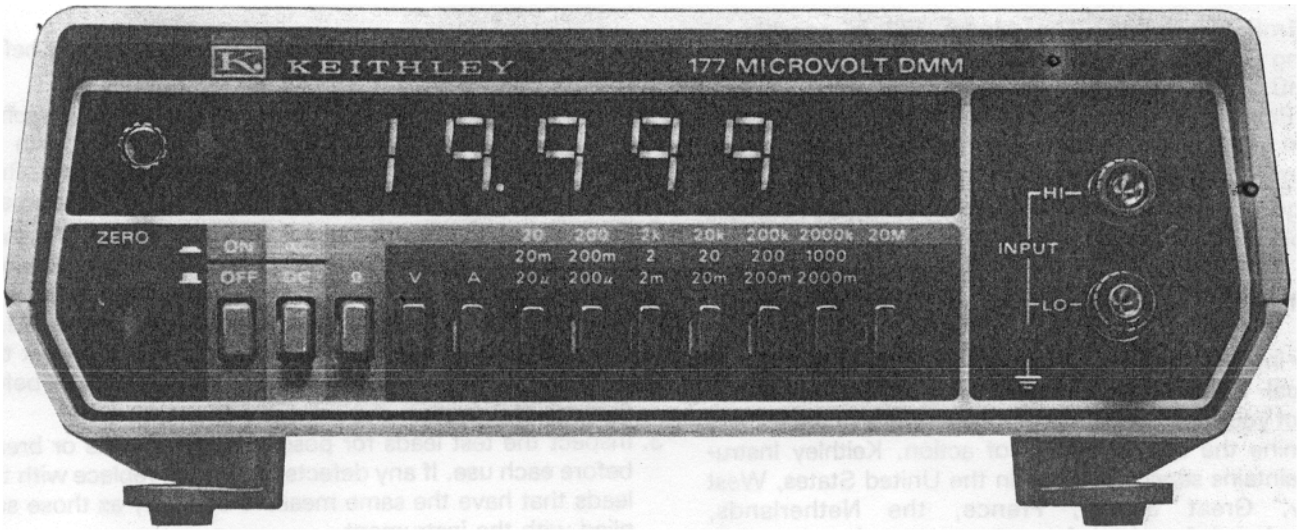

Figure 1-1. Model 177 Front Panel

SECTION 1
GENERAL INFORMATION

1.1 INTRODUCTION

The Keithley Model 177 Microvolt DMM is a versatile, highly sensitive digital multimeter which is used for measurement of DC and AC voltages, DC and AC currents, as well as resistance. For a complete summary of ranges for each of these five functions, refer to the specifications at the front of this manual. Ranges and functions are easily selected with front panel pushbuttons, while connections for all functions are easily made with a single set of front panel input terminals.

1.2 MODEL 177 FEATURES

1. 4½ Digit LED Display—An easy to read 4½ digit display shows 20,000 counts of information with automatic polarity indication.
2. 1μV/1mΩ Resolution—The Model 177 is capable of reading DC voltages as low as 1μV and resistances down to 1mΩ.
3. Front Panel Zero—The front panel zero control may be used to compensate for thermal offsets or lead resistance when making measurements.
4. Analog Output—An analog output of 1V/10,000 counts is available on the rear panel.

1.3 WARRANTY INFORMATION

Warranty information may be found inside the front cover of this manual. Should it become necessary to use the warranty, contact your nearest Keithley representative or the factory to determine the correct course of action. Keithley Instruments maintains service facilities in the United States, West Germany, Great Britain, France, the Netherlands, Switzerland and Austria. Information concerning the application, operation or service of your instrument may be directed to the applications engineer at any of these locations. Check inside the front cover of this manual for addresses.

1.4 MANUAL ADDENDA

Information concerning improvements or changes to the instrument that occur after the printing of this manual will be covered in an addendum sheet packed with the instrument. Be sure to review these changes before attempting to operate or service the instrument.

1.5 SAFETY SYMBOLS AND TERMS

The following safety symbols and terms are used in this manual or may be found on the Model 177.

The symbol  on the instrument indicates that the user should refer to the operating instructions.

The symbol on the instrument denotes that a potential of 1000V or more may be found present on the terminals. Standard safety practice should be observed when such dangerous voltages are encountered.

The **WARNING** heading used in this manual explains dangers that could result in personal injury or death if not handled properly. Be sure to read the **WARNING** information carefully before performing the associated procedure.

The **CAUTION** heading is used in this manual explains hazards that could damage the instrument.

1.6 SAFETY PRECAUTIONS

The following safety precautions should be observed before operating any digital multimeter.

1. This instrument is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read over the manual carefully before operating this instrument.
2. Exercise extreme caution when a shock hazard is present at the instrument's input. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V rms or 42.4V peak are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.
3. Inspect the test leads for possible wear, cracks or breaks before each use. If any defects are found, replace with test leads that have the same measure of safety as those supplied with the instrument.
4. For optimum safety do not touch the test leads of the instrument while power is applied to the circuit under test. Turn the power off and discharge all capacitors, before connecting or disconnecting the instrument.
5. Do not touch any object which could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface, which is capable of withstanding the voltage being measured.
6. Exercise extreme precaution when testing high energy power circuits (AC line or mains, etc.). Refer to the operation section of the manual.
7. Do not exceed the instrument's maximum allowable input as defined in the specifications and operation section.

1.7 SPECIFICATIONS

Detailed Model 177 specifications are located at the front of this manual.

1.8 UNPACKING AND INSPECTION

The Model 177 was carefully inspected, both mechanically and electrically, before shipment. Upon receiving the instrument, carefully unpack it from the shipping carton and check for any obvious signs of physical damage that might have occurred during shipment. Report any damage to the shipping agent at once. Retain the original packing materials in case reshipment becomes necessary. The following items are included with every Model 177 shipment.

1. Model 177 Microvolt DMM
2. Model 177 Instruction Manual
3. Additional accessories as ordered.

1.9 SCOPE OF THE MODEL 177 INSTRUCTION MANUAL

This manual contains information necessary to operate and service both the Model 177 and the optional Model 1788 Battery Pack and is divided into the following sections.

1. Section 2 contains operating information.
2. Information necessary to verify that instrument performance is within specified accuracy is located in Section 3.
3. Theory of operation is covered in Section 4.
4. Servicing information, including Model 1788 installation instructions, may be found in Section 5.
5. Replaceable parts information, component layouts and schematic diagrams are located in Section 6.

1.10 OPTIONAL ACCESSORIES

1.10.1 Power Options

The Model 177 can be powered by line voltage (105-125V at 50-60Hz or 210-250V at 50-60Hz—standard ranges) or the optional Model 1788 Rechargeable Battery Pack. (Optional line voltage ranges are described in Section 2.) The Model 1788 is available factory-installed or is field-installable. Installation and operating instructions are given in Section 2.

1.10.2 Cables and Connectors

Model 1681 Clip-On Test Lead Set—This set contains two 1.2m (48 in.) leads with banana plugs at one end and spring-action clip-on probes at the other end.

Model 1683 Universal Test Lead Kit—This kit contains two 1m (40 in.) test leads and 14 screw-in adapter tips. The tips consist of two alligator tips with boots, four banana plugs, phone tips, two spade lugs and four heavy duty tip plugs which permit connection of the Model 177 to virtually any source within its measurement range.

1.10.3 Probes and Shunts

Model 1600A High Voltage Probe—The Model 1600A High Voltage Probe extends the measurable DC voltage range up to 40kV. It has a 1000:1 division ratio, so that a reading of 1V on the DMM corresponds to 1kV (1000V). The Model 1600A has a basic accuracy of ±25% and an input resistance of 1000MΩ.

Model 1651 50-Ampere Shunt—The Model 1651 50-Ampere Shunt permits current measurements of up to 50A AC or DC. The shunt has a resistance of 0.001Ω±1%, so that a 50A current will correspond to a reading of 50mV. (0.0500V).

Model 1682A RF Probe—The Model 1682A RF Probe permits measurement of AC voltages at frequencies of 20kHz to 250MHz. AC to DC transfer accuracy is 1dB at 1V, and the input voltage range is 0.25V to 15V rms.

Model 1685 Clamp-On AC Current Probe—The Model 1685 Clamp-On Current Probe permits measurement of AC current by clamping around a single conductor, eliminating the need to interrupt the current path. The Model 1685 has a current conversion ratio of 0.1V/A with three ranges (2A, 20A, 200A). Accuracy is ±4% at 60Hz (±6% at 50Hz).

1.10.4 Carrying Case and Rack Mounts

Model 1684 Carrying Case—The Model 1684 Carrying Case is a hard vinyl case with a fitted foam insert to help protect the Model 177 from damage. There is also room in the case for the instruction manual and small accessories.

Models 1010 and 1017 Rack Mounting Kits—The rack mounting kits permit mounting one (1010) or two (1017) Model 177 DMMs in a 19 inch rack for convenient viewing.

1.10.5 Output Options

Model 1792 Isolated BCD Output—The Model 1792 converts displayed reading to an electrically isolated, latched and buffered parallel BCD format. Output data includes sign, overrange and busy. It is compatible with Model 177 serial number 14,500 and above, and can be either factory or field installed. Installation of the 1792 precludes installation of Models 1788 or 1793.

Model 1793 IEEE-488 Output—The Model 1793 converts displayed readings to IEEE-488 bus compatible outputs to permit automatic gathering of measurement data. Output includes 4½ digit ASCII data, sign an overrange. It operates in either talk-only or addressable modes. The Model 1793 is compatible with Model 177s serial number 16,500 and above, and can be either factory or field installed. Installation of the 1793 precludes installation of the Model 1788 or 1792.

SECTION 2
OPERATION

2.1 INTRODUCTION

This section provides information needed for preparation for use and operation of the Model 177 and Model 1788.

2.2 SAFETY PRECAUTIONS FOR HIGH ENERGY CIRCUITS

To optimize safety when measuring voltage in high energy distribution circuits, read and observe the directions in the following warning.

WARNING

Dangerous arcs of an explosive nature in a high energy circuit can cause severe personal injury or death. If the meter is connected to a high energy circuit when set to a current range, low resistance range or any other low impedance range, the circuit is virtually shorted. Dangerous arcing can result even when the meter is set to a voltage range if the minimum safety spacing is reduced.

When making measurements in high energy circuits use test leads that meet the following requirements:

1. Test leads should be fully insulated.
2. Only use test leads that can be connected to the circuit (e.g. alligator or spade lugs) for a hands-off measurement.
3. Use test leads that do not reduce the arc protection by decreasing the voltage spacing between conductors or terminals.

Use the following sequence when testing power circuits:

1. De-energize the circuit using the regular installed connect-disconnect device such as the circuit breaker, main switch, etc.
2. Attach the test leads to the circuit under test. Use appropriate safety rated leads for this application.
3. Set the DMM to the proper function and range.
4. Energize the circuit using the installed connect-disconnect device and make measurements without disconnecting the DMM.
5. De-energize the circuit using the installed connect-disconnect device.
6. Disconnect the test leads from the circuit under test.

2.3 PREPARATION FOR USE

The Model 177 is shipped ready-to-use on line power. The instrument may also be powered from rechargeable batteries (when the optional Model 1788 Rechargeable Battery Set is installed.)

2.4 OPERATION ON LINE POWER

The Model 177 DMM has a three-wire line cord which mates with third-wire grounded receptacles. Connect the instrument to AC line power as follows:

CAUTION

Connect only to the line voltage selected. Application of incorrect voltage can damage the instrument.

1. Set the LINE VOLTAGE switch on the back of the instrument to correspond to the line voltage available. Standard ranges are 105V to 125V and 210V to 250V AC as shown in Figure 2-1. Optional ranges of 90V to 110V and 180V to 220V AC are also available as shown in Figure 2-2. As indicated on their respective rear panels, the standard line voltage range instruments use an internal line fuse (F102) of 1/8A rating and the optional line voltage range instruments use a 3/16A fuse. See Section 5.

WARNING

Ground the instrument through a properly earth-grounded receptacle before operation. Failure to ground the instrument can result in severe injury or death in the event of short circuit or malfunction.

2. Plug the power cord into a properly grounded outlet. Operate the Model 177 DMM as described in paragraph 2.7.

2.5 OPERATION ON BATTERY PACK POWER

The Model 177 DMM may also be operated from rechargeable sealed lead-acid batteries contained in the optional Model 1788 Battery Pack. The battery pack will operate the Model 177 DMM for up to six hours. Circuits within the battery pack will automatically shut down the instrument when the battery charge is insufficient to maintain accurate readings. To install the Model 1788, refer to Section 5.

2.6 BATTERY CHARGING

The Model 1788 Battery Pack contains an integral battery charger. To charge the battery pack, install the battery pack in the Model 177 DMM as described above and proceed as follows:

1. Connect the instrument to line power as described in paragraph 2.4.

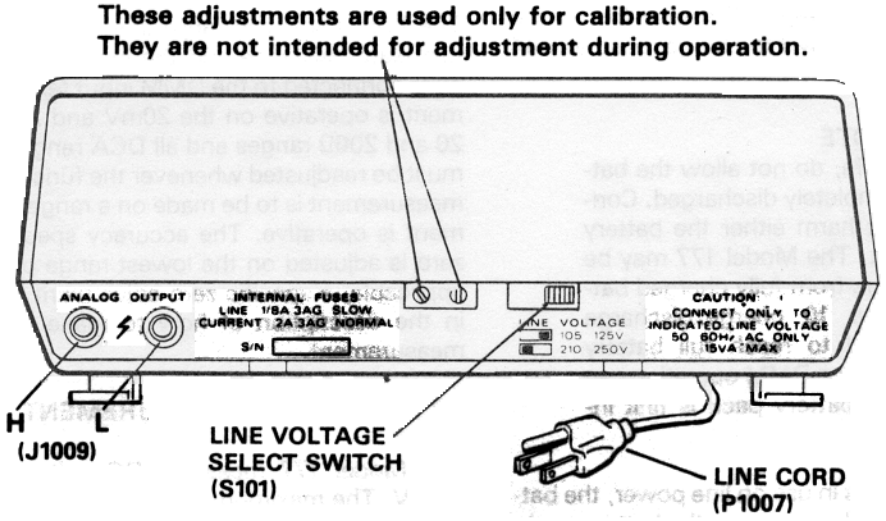

Figure 2-1. Rear View Of Standard Line Voltage Instrument

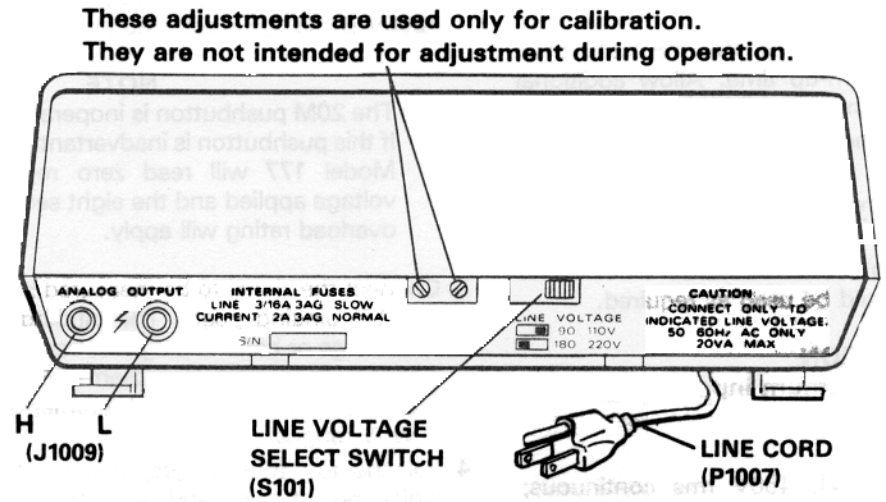

Figure 2-2. Rear View Of Optional Line Voltage Instrument

2. With the power switch off, the battery charge circuitry is automatically energized to charge the battery at the maximum rate. When the battery pack is first installed, or if it has completely discharged, allow it to charge for at least 14 hours in this condition.

NOTE

For maximum battery life, do not allow the battery pack to remain completely discharged. Constant charging will not harm either the battery pack or the instrument. The Model 177 may be operated up to six hours from fully charged batteries. However, since 10 charge/discharge cycles may be required to reach full battery capacity, less than six hours DMM operation can be expected when the battery pack is first installed.

3. When the Model 177 DMM is in use on line power, the battery charger maintains a trickle charge on the battery pack.

2.7 OPERATING INSTRUCTIONS

The basic operating instructions for the Model 177 DMM are outlined in the following steps, and condensed operating instructions are provided on the bottom cover of the instrument and contained in Table 2-1. These instructions should only be used after becoming completely familiar with the operation of the Model 177 through day-to-day use. Until this familiarity has been achieved, best performance and safest operation will be obtained by using the individual instructions provided in this section. Refer to Figure 2-3 and operate the DMM as follows:

1. Turn on the power by depressing the ON/OFF pushbutton and allow a 10 minute warm-up time. Allow additional warm-up for zero stability on lowest DMM and Ω ranges.
2. Select the function with the AC/DC, Ω, V, or A pushbuttons.
3. Select the range by depressing the appropriate pushbutton.
4. Connect the source to the INPUT terminals. Accessories described in Section 1 should be used as required.

CAUTION

Do not exceed the maximum input ratings shown below.

DCV	(20mV, 20mV, 2V): 450V rms continuous; 1200V peak momentary, for up to eight seconds per minute maximum. (20-1200V): 1200V peak.
ACV	(All Ranges): 1000V rms; 1400V peak; 10^7V•Hz.
DCA, ACA	(All Ranges): 2A, 250V DC or rms (fuse protected).
Ω	(All Ranges): 350V peak.

2.8 ZERO ADJUSTMENT

The front panel zero adjustment provides compensation for test lead resistance and thermal EMFs generated in the circuits connected to the DMM input terminals. The zero adjustment is operative on the 20mV and 200mV ranges of DCV, 20 and 200Ω ranges and all DCA ranges. In general, the zero must be readjusted whenever the function is changed and the measurement is to be made on a range where the zero adjustment is operative. The accuracy specifications assume that zero is adjusted on the lowest range of the function. Where applicable, a specific zero adjustment instruction is provided in the description of how to make the particular function measurement.

2.9 DC VOLTAGE MEASUREMENT

The Model 177 measures DC voltages from 1μV/digit to 1200V. The maximum displayed reading is 19999. Overrange is indicated by a flashing 0000 except on the 1200V range. On the 1200V range, the display can read beyond the maximum allowable input voltage. Use the Model 177 to measure DC volts as follows:

CAUTION

Do not exceed the maximum input voltage ratings, or instrument damage may occur.

1. Turn on power with ON/OFF pushbutton and select DC with the AC/DC pushbutton.
2. Select the desired range from the six ranges available. The decimal point is positioned by the range pushbuttons. The 1200V DC range is selected by the 1000 pushbutton.

NOTE

The 20M pushbutton is inoperative for DC volts. If this pushbutton is inadvertantly depressed, the Model 177 will read zero regardless of the voltage applied and the eight second per minute overload rating will apply.

3. Connect the signal to be measured between the INPUT HI and LO binding posts. The binding posts accept wires, spade lugs or banana plugs for ease of connecting the circuit to be measured. Low thermal cabling and connections are recommended for measurements on the 20mV and 200mV ranges.
4. For the top four ranges, merely observe the displayed digits, polarity sign and decimal point locations. The top four ranges are direct-reading in volts. Nominal settling time is located to within one digit of final reading.
5. For the 20mV and 200mV ranges, the front panel ZERO must be adjusted to obtain rated accuracy. This adjustment is necessary to compensate for thermal EMFs generated by the connections to the circuit to be measured. These voltages may be only a few microvolts or several tens of microvolts. The zero adjustment span is set up at the factory to allow at least ±75μV adjustment. To adjust zero, proceed as follows:

Tabe 2-1. Model 177 DMM Condensed Operating Instructions

Summary of Function, Ranges and Other Information					
Function	Range (Note 2)	Accuracy 18°C - 28°C (Note 1)	Input Impedance	Max. Input (Note 1)	Front Panel Zero
DCV (⎓)	20mV	0.04% Rdg +2D	10MΩ	1200V Momentary	Yes
	200mV	0.04% Rdg +1D			
	2V	0.03% Rdg +1D			No
	20V				
	200V			1200V	
	1200V	0.035% Rdg +1D			
ACV (≃) (Note 3)	200mV	0.5% Rdg +15D 100Hz-10kHz	1MΩ 75pF	1000V RMS 10^7V•Hz	No
	2V				
	20V				
	200V	0.7% Rdg +15D 45Hz-20kHz			
	1000V				
DCA	20μA	0.2% Rdg +2D	0.02V Burden	2A, 250V DC or rms (Note 4)	Yes
	200μA	0.2% Rdg +1D	0.2V Burden		
	2mA				
	20mA				
	200mA		0.25V Burden		
	2000mA		0.6V Burden		
ACA (Note 3)	200μA	0.8% Rdg +15D 45Hz-10kHz	0.2V Burden	2A, 250V DC or rms (Note 4)	No
	2mA				
	20mA				
	200mA		0.25V Burden		
	2000mA		0.6V Burden		
Ω (Ohms)	20	0.05% Rdg +3D	20mV F.S	350V Peak	Yes
	200	0.05% Rdg +2D	200mV F.S.		
	2k	0.04% Rdg +1D	2V at Full Scale 5V Max Open Circuit		No
	20k				
	200k				
	2000k				
	20M	0.1% Rdg +1D			

ANALOG OUTPUT: ±2V full scale, 5kΩ output resistance
Note 1: See manual for detailed information.
Note 2: Overrange is indicated by flashing 0000.
Note 3: True root mean square, crest factor = 3.
Note 4: Current fuse (installed internally) is 2A, 3AG normal blow. See Figure 5-4 for location.

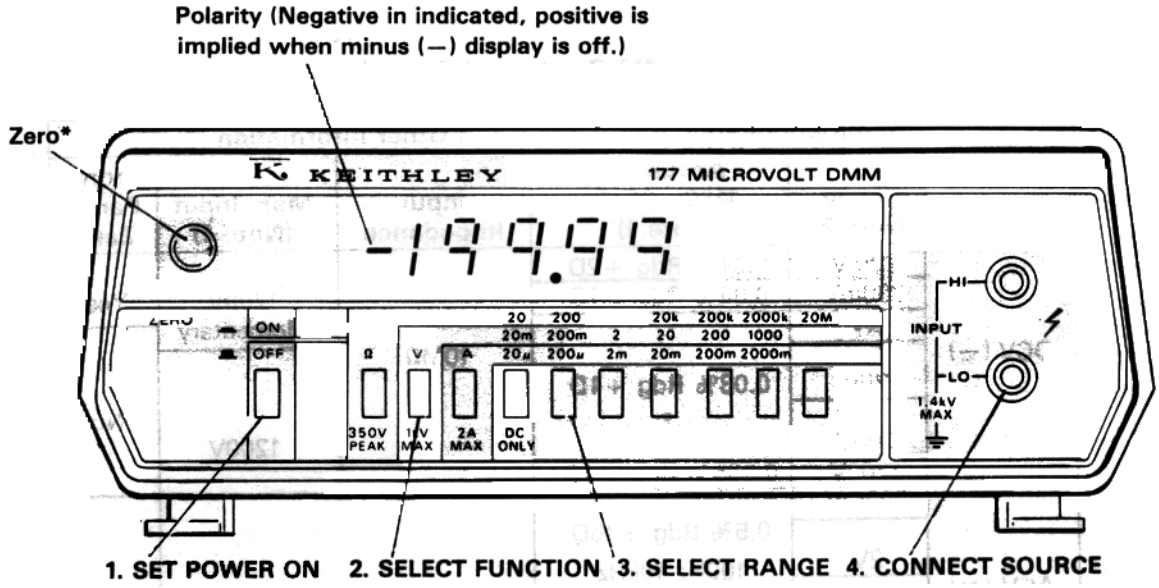

Figure 2-3. Operating Controls

NOTE

Due to the long thermal time constant of the 20mV range zero, a one hour warm-up time may be necessary to adjust zero to the final 1μV setting. Typically, only a one to three microvolt zero shift can be expected during this warm-up period, if the ambient temperature is within the specified 18° to 28°C and the instrument has not been subjected to temperature outside of this range. Thus, since the expected zero shift is both small and slow, normally zero can be adjusted and several measurements taken without having to achieve the final zero setting.

A. Make connections to the Model 177 as described above. For the best performance, connections should be made to the binding posts rather than using banana plugs.
B. Set the Model 177 to the 20mV range.
C. Disconnect the leads at the circuit to be measured and short them.
D. Allow the thermal EMFs generated at the connections to stabilize.
E. Adjust the front panel ZERO knob for a display indication of 0.000mV (a flashing ±0.001mV is permissible.)

NOTE

The ZERO control operates only on the 20mV and 200mV ranges. It has no effect on the other DC voltage ranges.

F. Make the measurements by applying the signal and reading the mV on the display. Nominal settling time for the 20mV range is three seconds to within one digit of final reading.

NOTE

An overload input to the Model 177 may cause temporary zero shift due to thermal gradients.

G. The zero setting for the 20mV range will also be valid for the 200mV range. Nominal setting time for the 200mV range is one second to within one digit of final reading.

6. The optional Model 1600A High Voltage Probe can be used with the Model 177 to measure DC voltage up to 40kV, at reduced accuracy.

2.10 AC VOLTAGE MEASUREMENT

The Model 177 measures AC voltages from 10μV to 1000V. The instrument measures the true root mean square (TRMS) of a signal within the frequency range of 45Hz to 20kHz. The maximum reading is 19999. Overrange is indicated by a flashing 0000 except on the 1000V range. On the 1000V range, the display can read beyond the maximum allowable input voltage. The maximum crest factor for rated accuracy is 3. AC accuracy is specified for 2000 counts and above. Nominal settling time for all AC voltage ranges is 2.5 second to within 10 digits of final reading. Use the Model 177 DMM to measure AC volts as follows:

1. Turn on power and set the AC/DC pushbutton to the in or AC position. Depress the V pushbutton.

NOTE

The 20μ and 20M ranges are inoperative for AC volts. If the 20μ pushbutton is inadvertantly

depressed, the display will read overrange, signalling the user to go to the next higher range. If 20M is depressed, the display will read zero regardless of the voltage applied. The method of calibrating the converter may yield an offset up to 125 digits with the Model 177 input shorted. This does not affect instrument accuracy.

2. Select the desired range from the five ranges available.

CAUTION
MAXIMUM ALLOWABLE INPUT VOLTAGE (All ranges): 1000V rms, 1400V peak, 10^7V•Hz maximum. Do not exceed the maximum rating. Instrument damage may occur.

3. Connect signal to be measured between INPUT HI and LO terminals. Observe the displayed digits and decimal point location. The 200mV range is direct-reading in mV and the remaining four ACV ranges are direct-reading in volts.
4. The crest factor (CF) is the ratio of the peak voltage to the rms voltage as follows:

$$CF = \frac{V_{PEAK}}{V_{RMS}}$$

NOTE
There will be some additional measurement error for signals with a crest factor greater than 3 (CF>3).

Typical crest factors are as follows:

Sine Wave	CF = 1.4
Square Wave	CF = 1
Triangular Wave	CF = 1.7
Positive pulse train (duty cycle CF = 3 is 0.11)	$CF = \sqrt{1/\text{duty cycle}}$

5. The optional Model 1682A RF Probe can be used with the Model 177 to measure 0.25V to 15V rms AC signals with a frequency of 20kHz to 250MHz (and above at reduced accuracy).
6. Refer to paragraph 2.14 for TRMS measurements of a signal with both AC and DC components.

2.11 RESISTANCE (Ω) MEASUREMENT

The Model 177 DMM measures resistance from 1mΩ/digit to 20MΩ. See Table 2-2 for ranges. Nominal settling times to within one digit of final reading are: three seconds on the 20Ω range; two seconds on the 2000kΩ and 20MΩ ranges; one second on the other four Ω ranges. Use the Model 177 to measure resistance as follows:

1. Turn on power and depress the Ω pushbutton.

CAUTION
MAXIMUM ALLOWABLE INPUT VOLTAGE (All ranges): 350V peak. Do not exceed maximum rating. Instrument damage may occur.

2. Connect the circuit to be measured to the INPUT binding posts and select the desired range from the seven available.

Table 2-2. Resistance Ranges

Range Setting	Maximum Reading	Full Scale Voltage**	Nominal Applied Current
20Ω*	19.999	20mV	1mA
200Ω*	199.99	200mV	1mA
2kΩ	1.9999	2V	1mA
20kΩ	19.999	2V	100μA
200kΩ	199.99	2V	10μA
2000kΩ	1999.9	2V	1μA
20MΩ	19.999	2V	0.1μA
*Front Panel Zero	All Ranges		
	Overrange: Flashing 0000	Open Circuit: 5V max.	Maximum Allowable Input: 350V Peak

**HI binding post (red) is negative.

3. Observe the displayed digits and decimal point to measure resistance using the 2k, 20k, 200k, 2000k and 20MΩ ranges. The full scale voltage drop for these ranges is 2V which is sufficient to cause forward conduction of semiconductor junctions. The HI (Red) terminal is negative. To measure a resistance in parallel with a semiconductor junction without turning on the junction, either reverse bias the junction or select the next higher Ω range. The latter method is possible because of the one decade reduction of applied test current, but will result in a measurement with 3½ digit accuracy. It is suggested that the 2kΩ range be used for diode testing. This range has a nominal 1mA test current and the displayed reading is the forward voltage drop in volts.

NOTE
The front panel ZERO control operates only on the 20Ω and 200Ω ranges. It has no effect on the other resistance ranges.

4. Before making measurements on the 20Ω or 200Ω ranges, adjust front panel ZERO on the 20Ω range to compensate for test lead resistance. Best performance will be obtained on the low ohm ranges when test connections are made to the binding posts, rather than using banana plugs. Adjust ZERO and make resistance measurements as follows:

A. Select 20Ω range.
B. Disconnect the test leads at the circuit to be measured and short them. If measurement is to be made right at the INPUT terminals (no test leads used) place a short, such as a piece of copper wire, across the binding posts.
C. Adjust the front panel ZERO knob for a display indication of 0.000 ±0.001Ω (flashing). The nominal ZERO adjustment span is 200mΩ.

NOTE

The specified accuracy for the 20Ω and 200Ω ranges assumes that ZERO was adjusted on the 20Ω range. Re-adjust zero on the 20Ω range each time that a different set of leads is used or whenever measurements have been made on either the two lowest DC voltage ranges or any DC current range. The zero setting for those measurements will be different than the zero setting of ohms. Also, re-adjust zero whenever the instrument is used outside the temperature range of 18° to 28°C.

D. Reconnect the test leads to the circuit to be measured.
E. Select either 20Ω range or 200Ω range. Read the displayed digits and decimal point.

NOTE

An input overload to the Model 177 may cause a temporary zero shift due to thermal gradients.

2.12 DC CURRENT MEASUREMENT

The Model 177 measures DC current from 1nA/digit to 2A, over six ranges (the 20M range is not operative and the instrument will read zero if 20M pushbutton is depressed). The maximum reading is 19999. Overrange is indicated by a flashing 0000. Overload is protected by fuse F101, a 2A 3AG normal-blow fuse. Nominal settling time for DC current ranges is one second to within one digit of final reading except three seconds on 20μA range.

1. Before making DC current measurements, the front panel ZERO must be adjusted on the 20μA range. This adjustment is necessary to remove any offset that was introduced by adjusting ZERO for a low DC voltage measurement or a low Ω measurement. This adjustment will also be necessary whenever the instrument is used outside of the temperature range of 18° to 28°C. The specified accuracy for the DC current ranges assumes that ZERO was adjusted on the 20μA range. Adjust ZERO as follows:
   A. Disconnect all circuits from the Model 177 INPUT terminals. The INPUT terminals must have an open circuit.
   B. Turn on power and set the AC/DC pushbutton to the out or DC position.
   C. Depress A and 20μ pushbuttons.
   D. Adjust front panel ZERO knob for a display indication of 0.000μA ±.001 flashing.
2. After adjusting ZERO, use the Model 177 to measure DC current as follows:

CAUTIONS

Do not install a larger capacity fuse than the one originally supplied (2A). Current fuse F101 (shown in Figure 5-4) protects the instrument against over-current.

   A. Select the desired range from the six ranges available.
   B. Connect the circuit to be measured to the INPUT terminals.
   C. Read the displayed polarity, digits and decimal point. Select the next higher range if overrange is indicated.

2.13 AC CURRENT MEASUREMENT

The Model 177 measures AC current from 10nA/digit to 2A, over five ranges. (The 20μA and 20M ranges are not operative. See note below.) The 200μA range is direct-reading in microamperes. The remaining AC current ranges are direct-reading in milliamperes. The maximum reading is 19999. Overrange is indicated by a flashing 0000. Overload is protected by fuse F101, a 2A, 3AG normal-blow fuse. The instrument measures the true root mean square (TRMS) of waveforms in the frequency range of 45 to 10kHz. Use the Model 177 to measure AC current as follows:

1. Turn on power and set the AC/DC pushbuttons to in or AC position. Depress the A pushbutton.

CAUTION

Do not install a larger capacity fuse than the one supplied. Current fuse F102 (shown in Figure 5-4) protects the instrument against over current.

2. Connect the circuit to be measured to the INPUT terminals and select the desired range from the five ranges available.

NOTE

The 20μA and 20M ranges are not operative for AC current measurements. If the 20μA pushbutton is inadvertently depressed, an overrange will be indicated, signalling the user to go to the next higher range. If the 20M pushbutton is depressed, the instrument will read zero.

3. Read the displayed digits and decimal point.

NOTE

AC accuracy is specified for 2000 counts and above. The method of calibrating the converter may yield an offset up to 80 digits with the Model 177 input shorted. This does not affect instrument accuracy. There will be some additional measurement error for signals with a crest

factor greater than 3 (CF>3). Refer to paragraph 2.10 for information on how to determine the crest factor of a waveform.

4. Refer to paragraph 2.14 for TRMS measurements of a signal with both AC and DC current components.

2.14 TRMS MEASUREMENTS (AC + DC)

The Model 177 measures the AC component of a waveform and does not measure the DC component. Use the Model 177 to measure TRMS of a signal which has both AC and DC components as follows:

1. Measure and record the AC and DC components separately.
   A. Refer to paragraph 2.9 for DC voltage measurement.
   B. Refer to paragraph 2.10 for AC voltage measurement.
   C. Refer to paragraph 2.12 for DC current measurement.
   D. Refer to paragraph 2.13 for AC current measurement.
2. Compute the TRMS value using the following equation:

$$E_{TRMS} = \sqrt{E_{DC}^2 + E_{AC}^2} \text{ OR } I_{TRMS} = \sqrt{I_{DC}^2 + I_{AC}^2}$$

2.15 ANALOG OUTPUT

The rear panel accessible ANALOG OUTPUT provides a ±2V full scale DC signal (10k counts = 1V). The ANALOG OUTPUT is operable for all instrument ranges and functions. The output polarity of the analog voltage is negative for the ohms (Ω) function, positive for AC function and non-inverting for DC functions. The effective analog output resistance is 5kΩ (4kΩ in series with the HI output to protect the Model 177 against externally applied voltage and 1kΩ between input LO and analog output LO to prevent a ground loop when connection is made to a grounded load, oscilloscope or recorder). The analog output voltage is compatible with most modern analog recorders and may be used to determine signal changes with respect to time or other variables. With respect to the signal input and analog output, the Model 177 acts as an amplifier (for mV signals), an attenuator (for kV signals) or a converter to DC volts (for AC current or resistance signals). Output accuracy is the same as the display except on ohms; up to ±0.05% error can be expected due to the ratio-metric method used. The analog output floats at input LO. For this reason, do not connect a voltage source across INPUT LO and ANALOG LO. This will result in a measurement error and may damage the Model 177 if the voltage is greater than 15V. When the instrument is in an overrange condition, up to ±15V DC may be at the ANALOG OUTPUT dependent upon the function, range and level of the input signal.

2.16 TILT BAIL ADJUSTMENT

The tilt bail of the Model 177 may be used to elevate the instrument to a convenient viewing height. To adjust the bail, pull the bail out from each side of the case and rotate it to the desired position. Release the bail to allow it to lock into position.