

SPECIFICATIONS

DC VOLTS

RANGE	RESOLUTION	ACCURACY (1 YEAR)
		18°-28°C ±(%rdg + counts)
200mv	10 uV	0.03+2
2 v	100 uV	0.03+1
20 v	1mV	0.03+1
200 v	10mV	0.03 + 1
1000 v	100mV	0.03 + 1

INPUT RESISTANCE: 11MΩ on 200mV, 2V and 20V ranges. 10MΩ on 200V and 1000V ranges. (Greater than 1000MΩ on the 200mV and 2V ranges with all function buttons in the out position).

NORMAL MODE REJECTION RATIO: Greater than 60dB at 50Hz, 60Hz ± 0.15%.

MAXIMUM ALLOWABLE INPUT: 1000V DC or peak AC (less than 10 seconds per minute on the 200mV and 2V ranges; 300V rms continuous).

SETTLING TIME: 1 second to within 1 count of final reading on range.

dB MODE (ref: 600Ω):

Accuracy: ±(0.02dB+1 count) (above -78dBm).

Resolution: 0.01dB above 5% of range.

TRMS AC VOLTS

RANGE	ACCURACY (1 YEAR) *				
	18°-28°C ±(%rdg+counts)				
	20Hz-50Hz	50Hz-10kHz	10kHz-20kHz	20kHz-50kHz	50kHz-100kHz
2v - 750v	1+20	0.5+20	1 +40	2.5+75	5+200
200mV	1+20	0.5+20	1.5+40	8 +75	-

*Above 1800 counts.

MAXIMUM ALLOWABLE INPUT: 750V rms, 1000V peak (less than 10 seconds per minute on the 200mV range; 300V rms continuous). 10³V•Hz maximum.

3dB BANDWIDTH: 300kHz typical.

INPUT IMPEDANCE: 10MΩ paralleled by less than 75pF on 20V, 200V and 1000V ranges. 11MΩ on 200mV and 2V ranges. Capacitively coupled.

SETTLING TIME: 2 seconds to within 15 counts of final reading on range.

dB MODE (ref: 600Ω):

RANGE	INPUT	ACCURACY (± dBm)			
		20Hz-10kHz	10kHz-20kHz	20kHz-50kHz	50kHz-100kHz
2V-750V	200mV to 750 V (-12 to +59.8dBm)	0.2	0.26	0.56	1.2
200mV	20mV to 200mV (-32 to -12 dBm)	0.2	0.3	1	-
	2mV to 20mV (-52 to -32 dBm)	2	3	-	-
	1mV to 2mV (-58 to -52 dBm)	2*	-	-	-

*Up to 1kHz.

Resolution: 0.01dB above 5% of range.

OHMS

RANGE	RESOLUTION	ACCURACY (1 YEAR)	MAX. VOLTAGE
		18°-28°C + (% rdg + counts)	ACROSS UNKNOWN ON RANGE
200 Ω	10mΩ	0.05+2**	0.2V
2 kΩ	100mΩ	0.05+1	2.0V
20 kΩ	1 Ω	0.05+2	0.2V
200 kΩ	10 Ω	0.05+1	2.0V
2MΩ 20MΩ 200MΩ	100 Ω 1 kΩ 100 kΩ	0.05+2	0.2V
		0.2 +1	2.0V
		2.0 +1	2.0V

*Appropriate range selected automatically. **With zero set by REL function.

MAXIMUM ALLOWABLE INPUT: 450V DC or peak AC.

OPEN-CIRCUIT VOLTAGE: +5V.

DIODE TEST: Display reads junction voltage up to 2V. Test current: 0.7mA nominal.

SETTLING TIME: 2 seconds to within 1 count of final reading on range.

DC AMPS

RANGE	RESOLUTION	MAXIMUM VOLTAGE	ACCURACY (1 YEAR)
		BURDEN	18°-28°C ±(%rdg + counts)
200 μA	10 nA	0.3V	0.15+2
2mA	100 nA	0.3V	0.15+2
20mA	10 μA	0.3V	0.15+2
200mA	100 μA	0.3V	0.2 +2
2000mA	1000 μA	0.8V	0.2 +2
10 A	1mA	0.3V	0.75+2*

*Above 5A derate 0.15% rdg per amp for self-heating.

OVERLOAD PROTECTION: mA Input: 2A fuse (250V), externally accessible. 10A Input: 20A for 15s, unfused.

SETTLING TIME: 1 second to within 1 count of final reading.

TRMS AC AMPS

RANGE	MAXIMUM VOLTAGE BURDEN	ACCURACY (1 YEAR)'		
		18°-28 °C ± (% rdg + counts)		
		20Hz-50Hz	50Hz-10kHz	10kHz-30kHz
200 μA -20mA	0.3V	1 +20	0.8+20	2+50
200mA	0.3V	1 +20	0.8+20	-
2000mA	0.8V	1 +20	0.8+20	-
10 A	0.3V	1.5+20**	1 +20**	-

*Above 1800 counts. ● 1kHz max. Above 5A derate 0.15% rdg/amp for self-heating.

SETTLING TIME: 2 seconds to within 15 counts of final reading.

GENERAL

DISPLAY: 4.5digit LCD, 0.5" height; polarity, function, range, and status indication.

RANGING: Auto or manual on DCV, ACV, and ohms; manual on ACA and DCA.

AUTORANGING TIME: 300ms per range.

RELATIVE: Pushbutton allows zeroing of on range readings. Allows readings to be made with respect to baseline value. Front panel annunciator indicates REL mode.

DATA LOGGER and MIN/MAX: 100 reading storage capacity; records data at one of six selectable rates from 3 rdg/s to 1 rdg/hr. Also detects and stores maximum and **minimum readings continuously while** in the data logger mode.

CONVERSION RATE: 3 readings/second.

OVERRANGE INDICATION: "OL" displayed.

CREST FACTOR (ratio of peak value to rms value), AC FUNCTIONS: 3.

MAXIMUM COMMON MODE VOLTAGE: 500V peak.

COMMON MODE REJECTION RATIO (1kΩ unbalance) Greater than 120dB at DC, 50Hz, 60Hz ±0.15%. Greater-than 60dB in AC volts.

TEMPERATURE COEFFICIENT (0°-18°C & 28°-50°C): 0.1 X applicable accuracy specification/ °C except ± (0.07% +2)/°C for 50Hz-10kHz on ACV.

ENVIRONMENT: Operating: 0° to 50°C; less than 80% relative humidity up to 35°C; linearly derate 3% RH/°C, 35° to 50°C. Storage: -25° to -160°C.

POWER: 105-125V or 210-250V (external switch selected), 90-110V available: 50-60Hz, 12V-A. Optional 6-hour battery pack, Model 1758.

DIMENSIONS, WEIGHT: 89mm high X 235mm wide X 275mm deep (3 1/2" X 9 1/4" X 10 3/4"). Net weight: 1.8kg (3lbs., 14 oz.).

ACCESSORIES SUPPLIED: Model 1751 Shrouded Test Leads, instruction manual.

Prices and specifications subject to change without notice.

d B – Decibel selected.
 STO – Data being stored.
 RCL-Data being recalled. RCL flashes when buffer is full during logging cycle.

2.4.2 Front Panel Controls

ON/OFF-Pressing in this pushbutton turns the Model 175 on. Releasing (out) this pushbutton turns the instrument off.
 REL (Relative)-This pushbutton allows readings to be made with respect to any baseline value. Also allows zeroing of on range readings. See paragraph 2.7.2 for more detailed information on REL.

dB-This pushbutton selects the dB function and is used along with the ACV or DCV function. Measurements are made in dBm referenced to 600Ω. REL can be used to make any voltage level the 0dB reference point for dB measurements.

DATA LOGGER-Has min/max and 100 point reading storage capacity; records data at one of six selectable rates from every reading to 1 rdg/hr. Records maximum and minimum conversion during the period the data logger is active at the rate of 3/sec.

1. STO/CLR- Pressing this button initiates the logging sequence. Pressing the button a second time shuts off the data logger.
2. RCL-Pressing and holding this button in scrolls the data pointer. To read the data at a particular point, simply release the button.

AC/DC-This switch is used along with the volts (V), current (A), and dB functions. Depressing (in) this pushbutton selects AC and releasing (out) this pushbutton selects DC.

V-Depressing this pushbutton selects the volts function.

Q-Depressing this pushbutton selects the ohms function.

The AC/DC pushbutton must be released (out).

A- Depressing this pushbutton selects the current function.

Range Push Buttons

1. AUTO- Depressing this pushbutton causes volts and ohms to autorange. In current, it selects the 10A range (no autoranging in current).

2.4 FRONT PANEL FAMILIARIZATION

The following paragraphs and Figure 2-1 provide a brief description of the display, front panel controls and input terminals.

2.4.1 Display

The Model 175 has a 4 ½ digit liquid crystal display (LCD). The minus sign is displayed. The plus sign is implied by the absence of the minus sign. The following annunciators are displayed on the LCD.

BAT-Low battery indicator for the Model 1758.

AC-AC selected (DC implied by absence of AC annunciator).

mV or V-Millivolts or volts selected.

Ω, kΩ or MQ-Ohms, kilohms or megohms selected.

μ, mA or A-Microamps, milliamps or amps selected.

RMT (Remote)- Model 175 being controlled over the IEEE-488 bus (Model 1753 installed).

C-Model 175 in calibration mode.

AUTO-Autorange selected.

REL- Relative selected.

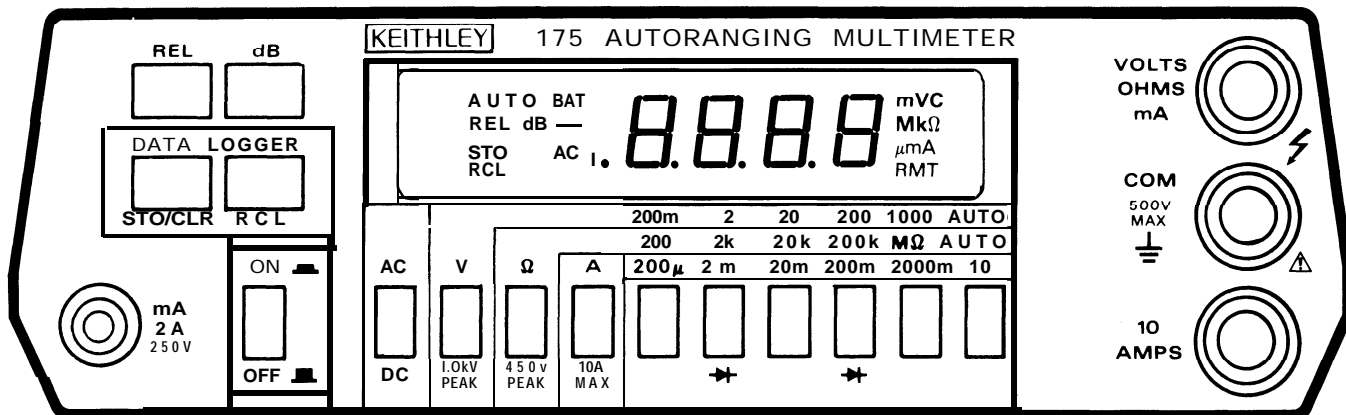


Figure 2-1. Model 175 Front Panel

2. Manual ranging is accomplished by depressing the appropriate range button.

2.4.3 Input Terminals

The input terminals are intended to be used with safety shrouded test leads to help minimize the possibility of contact with live circuits. Safety shrouded test leads are supplied with the Model 175.

VOLTS/OHMS/mA and COM (Red and Black)-Use this pair of terminals for all volt, ohm, milliamp and dB measurements.

10 AMPS and COM (White and Black)-Use this pair exclusively for measuring current up to 10A (up to 20A for 15 seconds).

2.4.4 Current Fuse Replacement

The current fuse protects the 200 μ A through 2000mA ranges from an input current greater than 2A. To replace the current fuse, perform the following steps:

1. Turn off the power and disconnect the power line and test leads.
2. Place the end of a flat-blade screwdriver into the slot in the fuse holder on the front panel. Press in slightly and rotate the fuse carrier one-quarter turn counterclockwise. Release pressure and remove the fuse carrier and the fuse.

3. Remove the defective fuse and replace it with the following type: 2A, 250V, 3AG, normal-blow Keithley part number FU-13, or equivalent.

CAUTION

Use only the recommended fuse type. If a fuse with a higher current rating is installed, instrument damage may occur.

2.5 ERROR MESSAGES

Table 2-1 lists the error messages associated with basic front panel operation. Note that the instrument has a number of other messages that are discussed in the appropriate sections of this manual.

2.6 OPERATING CONDITIONS

2.6.1 Environmental Conditions

All measurements should be made at an ambient temperature within the range of 0°C to 50°C, and with a relative humidity of 0% to 80% up to 35°C. For instruments above 35°C derate humidity 3% per °C up to 50°C. If the instrument has been subjected to extremes of temperature, allow sufficient time for internal temperatures to reach environmental conditions. Typically, it takes one hour to stabilize a unit that is 10°C (18°F) out of specified temperature range.

Table 2-1. Error Messages




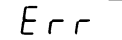
Display	Message	Comments
	RAM Error	Model 175 locks up. See Section 5 for troubleshooting information.
	Calibration Error (NVRAM Failure)	Model 175 locks up, but operation can be restored by pressing any one of the four momentary pushbuttons. If restored, calibration is invalid as indicated by the flashing "C" annunciator. See Section 5 for troubleshooting information.
	Overrange	Overrange input applied to the Model 175. Leading minus sign indicates that input signal has a negative value.
	Invalid Ω Function	"AC" and " Ω " annunciators flash. Correct problem by releasing (out) AC/DC pushbutton.

Table 2-2. Model 175 Maximum Allowable Inputs

Function	Ranges	Maximum Allowable Inputs
DCV	200mV, 2V	1000VDC or peak AC for less than 10sec per minute. 300Vrms continuous.
	20-l oov 200mV	1000VDC or peak AC. 750Vrms 1000V peak for less than 10sec per minute. 300Vrms continuous. $10^7V \cdot Hz$ maximum.
ACV	2-750V	750Vrms, 1000V peak. $10^7V \cdot Hz$ maximum.
	200 μ -2000mA	2A, 250VDC or rms (fuse protected). 10A continuous; 20A for 15sec (unfused).
Ω	All	450VDC or peak AC

2.6.2 Maximum Allowable Inputs

Table 2-2 lists the maximum allowable inputs for the Model 175.

2.7 BASIC BENCH MEASUREMENTS

Basic measurement techniques for using the Model 175 to measure AC and DC volts, resistance, AC and DC current and dB are covered in the following paragraphs. Also included is the operation of the MIN/MAX and 100 point data logger.

WARNING

Before operating the Model 175, observe the safety precautions found preceding Section 1. When testing high energy power circuits follow the procedure found in paragraph 2.2 High Energy Circuit Precautions. Failure to observe these and other safety precautions found in this manual could result in severe injury or death.

The COM terminal on the Model 175 is designed to float above earth ground to avoid ground loop problems.

WARNING

Hazardous voltages may be applied to the COM terminal. The maximum allowable voltage between the COM terminal and chassis ground is 500V. Destruction of insulation, which could present a shock hazard, may occur if the 500V maximum is exceeded.

CAUTION

Do not exceed the maximum input limits shown in Table 2-2.

2.7.1 Power-Up

NOTE

The software revision level of the Model 175 can be displayed upon power-up by running the diagnostic program. See Section 5, Maintenance, for more information.

Turn on the Model 175 by pressing in the ON/OFF switch. The following will occur:

1. Reset-All zeros will be briefly displayed before going into the measurement mode.
2. RAM Test-If this test fails the Model 175 will lock up with zeros displayed.
3. NVRAM Test-If this test fails the display will show the error message "cErr"

Refer to Table 2-1 for more information pertaining to error messages.

2.7.2 Relative Mode

When the relative mode is selected with an on-scale reading on the display the following occurs:

1. The REL annunciator is displayed.
2. The next reading is stored.
3. The stored reading is then algebraically subtracted from all subsequent readings and displayed.

A REL level can be established for any measurement function (Volts, Ohms, Amps and dB) and is effective only on that function. Changing functions will not affect a REL level already established. However, if another REL level is set (on any function) the previous REL level will be cancelled. For example, place the 175 in the Ω function and select the **200 Ω** range. Short the test leads and press the REL button. Note that the REL annunciator is on. Select DCV and note that the REL annunciator is off, indicating that there is not a REL level established for DCV. Switch back to Ω and note that the REL level is still there. Again, go to DCV and set a REL level of +1V. The REL annunciator will go on. Switch back to Ω and note that the REL annunciator is off, indicating that the REL level for Ω is cancelled.

Once a REL level is established for a measurement function, that stored level will be the same regardless of what range the Model 175 is on. For example, if +1V is established as the REL level on the 20VDC range, +1V will also be the REL level on the 1000VDC range.

It is important to note that the use of REL reduces the dynamic range of measurements by that level. For instance, assume that the REL level is +1V and the Model 175 is manually set to the 2V range. The maximum positive displayed reading, before overranging, would be +0.9999V. This is because the A/D converter would be seeing 1.9999V (maximum) from the input. Thus, the dynamic range of measurement is -1.9999V to +0.9999V (2.9998V) as compared to the normal -1.9999V to +1.9999V (3.9998V). The dynamic range of measurement has been reduced by 1V. The effects on dynamic range can be reduced by selecting a higher range or using autorange.

2.7.3 DC Voltage Measurements

The Model 175 can make DC voltage measurements between **10 μ V** and 1000V. The basic procedure is as follows:

1. Connect the test leads to the VOLTS and COM terminals of the Model 175.
2. Select the DCV function.
3. Select a range consistent with the expected voltage. For automatic range selection, press in the AUTO pushbutton.

NOTE

Manual ranging is recommended for routine measurements above 200V.

- Connect the test leads to the source as shown in Figure 2-2. If the positive source terminal is connected to the COM terminal of the instrument, the display will show a negative value. If the negative source terminal is connected to the COM terminal, the display will show a positive value.
- Observe the display; if the "OL" message is shown, select a higher range until a normal reading is shown. Always use the lowest possible range for the best resolution.
- Take the reading from the display.

NOTE

High input impedance ($V1000M\Omega$) DC volts measurements can be made on the 200mV and 2V ranges by releasing (out) all the function pushbuttons (AC/DC, V, Ω , A).

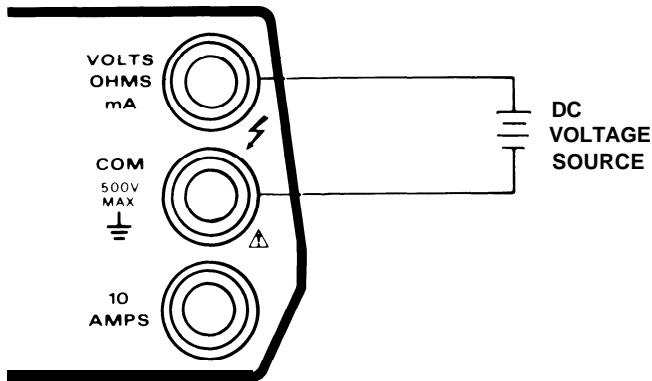


Figure 2-2. DC Voltage Measurements

2.7.4 TRMS AC Voltage Measurements

The Model 175 can make TRMS AC voltage measurements between $10\mu V$ and 750V. Proceed as follows:

- Connect the test leads to the VOLTS and COM terminals of the Model 175.
- Select the ACV function.
- Select a range consistent with the expected voltage. For automatic range selection, press in the AUTO pushbutton.

NOTE

Manual ranging is recommended for routine measurements above 200V.

- Connect the test leads to the source as shown in Figure 2-3.
- Observe the display; if the "OL" message is shown, select a higher range until a normal reading is shown. Always use the lowest possible range for the best resolution.
- Take the reading from the display.

NOTE

See paragraph 2.8 for TRMS considerations.

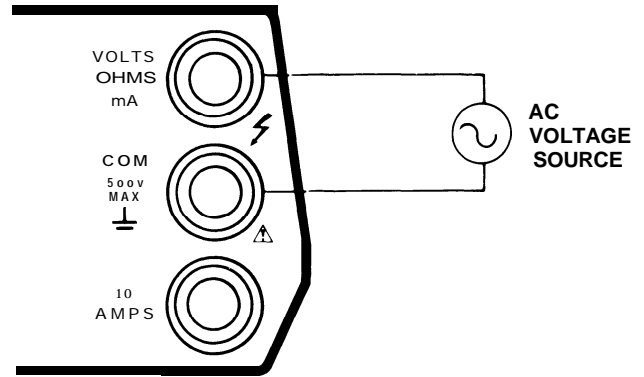


Figure 2-3. TRMS AC Voltage Measurements

2.7.5 Resistance Measurements

The Model 175 can make resistance measurements between $10m\Omega$ and $200M\Omega$. The $2M\Omega$, $20M\Omega$ and $200M\Omega$ ranges will autorange when the $M\Omega$ pushbutton is pressed in. Proceed as follows to make resistance measurements:

- Connect the test leads to the OHMS and COM terminals of the Model 175.
- Select the Ω function.

NOTE

The message "Err" and flashing Ω and AC annunciators will be displayed if the AC/DC pushbutton is pressed in. This is an invalid mode. To correct, simply release (out) the AC/DC pushbutton.

- Select a range consistent with the expected resistance. For automatic range selection, use the autorange mode.

NOTE

Zeroing may be necessary to compensate for test lead resistance on the 200Ω and $2k\Omega$ ranges. Zero the display as follows:

- Short the test leads together.
 - Press the REL pushbutton. The display will zero.
 - Proceed to step 4.
- Connect the test leads to the resistance to be measured as shown in Figure 2-4.
 - Observe the display; if the "OL" message reading is shown, select a higher range until a normal reading is shown. Always use the lowest possible range for the best resolution.
 - Take the reading from the display

NOTE

It is helpful to shield resistances greater than $10^6\Omega$ ($1M\Omega$) if a stable reading is expected. Place the resistance in a shielded enclosure and electrically connect the shield to COM of the Model 175.

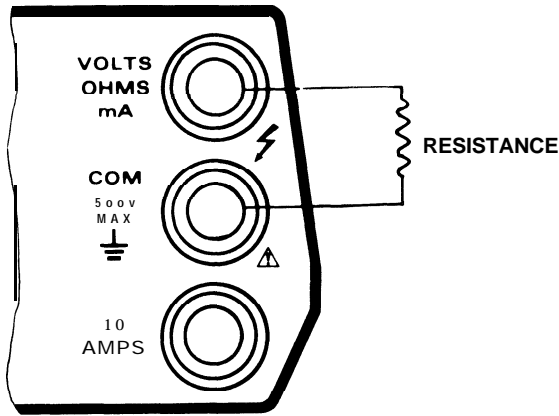


Figure 2-4. Resistance Measurements

2.7.6 Current Measurements (DC or TRMS AC)

The Model 175 can make DC or TRMS AC current measurements between $10\mu\text{A}$ and 10A (20A for 15 seconds). If the expected current level is in question, make the initial measurement with the 10A range. This will help prevent the inadvertent blowing of the 2A current fuse.

NOTE

For routine measurements above 10A it is recommended that the Model 1651, 50-Ampere current shunt be used.

1. For current measurements between 2000mA and 20A.

- A. Connect the test leads to the 10 AMPS and COM terminals of the Model 175.

NOTE

The test leads used must be capable of handling 20A and it is recommended that they be twisted (see Figure 2-5) to minimize external fields which could affect the Model 175 or other equipment. Also, keep the test leads as short as possible to minimize voltage drop.

- B. Select the ACA or DCA function.
- C. Select the 10A range. Current does not autorange.
- D. Connect the test leads to the current source as shown in Figure 2-5 and make the reading from the display.

NOTE

Up to 5A may be applied continuously without degradation of the measurement due to self-heating effects. Above 5A derate 0.15% rdg per amp for self-heating. For currents between 10A and 20A, specified accuracy can only be obtained when measurements are limited to a maximum of 15 seconds.

2. For current measurements up to 2000mA:

- A. Connect the test leads to the mA and COM terminals of the Model 175.

- B. Select the ACA or DCA function.
- C. Select an appropriate range for the expected current. Current measurements cannot autorange.
- D. Connect the test leads to the current source as shown in Figure 2-6. If an overrange indication is displayed select a higher range until a normal reading is shown. Use the lowest possible range for the best accuracy.
- E. Make the reading from the display.

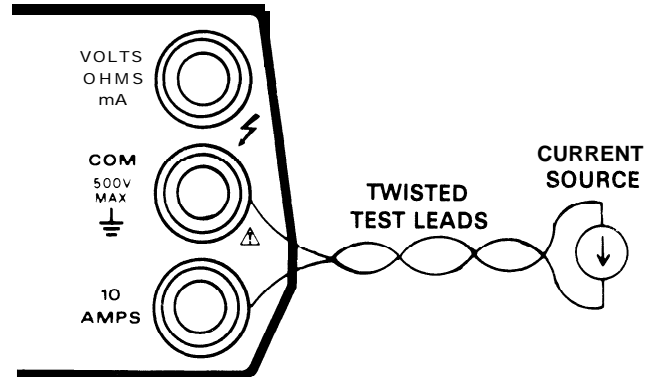


Figure 2-5. Current Measurements Between 2000mA and 20A

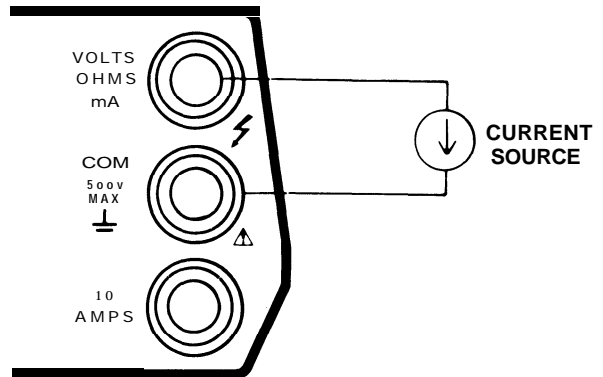


Figure 2-6. Current Measurements up to 2000mA

2.7.7 AC Plus DC Measurements

Use the Model 175 to measure TRMS on a signal which has both AC and DC components as follows:

1. Measure and record the TRMS AC component as described in paragraph 2.7.4.
2. Measure and record the DC component as described in paragraph 2.7.3.
3. Compute the rms value from the following equation:

$$E_{\text{RMS}} = \sqrt{E_{\text{DC}}^2 + E_{\text{AC}}^2}$$

2.7.8 dB Measurements

The dB function makes it possible to compress a large range of readings into a much smaller scope. The relationship between dB and voltage can be expressed by the following equation.

$$\text{dB} = 20 \log \frac{V_{\text{OUT}}}{V_{\text{REF}}}$$

Tables 2-3 and 2-4 list the dB specifications for DC volts and AC volts.

The Model 175 can make dBm measurements referenced to the standard 600Ω impedance or to other impedances. The relative feature allows measurements in dB independent of impedance.

The basic procedure for placing the instrument in the dB mode is to first select AC or DC volts and then press the dB button. Note that once dB is selected (dB annunciator on), pressing in the Ω or A function pushbuttons will turn dB off.

1. dBm Measurements with 600Ω Reference Impedance

dBm is defined as decibels above or below a 1mW reference. The standard reference impedance of the Model 175 is 600Ω . What that means is that the Model 175 is designed to read 0dBm when the calculated voltage needed to dissipate 1mW through a 600Ω impedance is applied to the Model 175. That calculated voltage level is 0.7746V as derived from the basic power equation.

$$E = \sqrt{P \cdot R}$$

$$E = \sqrt{10^{-3}W \cdot 600\Omega}$$

$$E = 0.7746V$$

Thus with a 600Ω reference impedance the Model 175 will read 0dBm whenever 0.7746V is applied.

NOTE

Do not confuse reference impedance with input impedance. The input impedance of the instrument is still $10M\Omega$ (see specifications) in the dB mode.

To make dBm measurements referenced to 600Ω , proceed as follows:

- A. Connect the test leads to the VOLTS and COM terminals of the Model 175.
- B. Select the ACV or DCV function.
- C. Select autorange for optimum resolution.
- D. Press the dB button.
- E. Connect the test leads to the voltage source.
- F. Make the dBm reading from the display.

2. dBm Measurements with Other Reference Impedances

dBm measurements can be made with other reference impedances. The most convenient method for using other reference impedances is to algebraically subtract the calculated dB offset for the desired reference impedance from the reading on the display of the Model 175. Table 2-5 lists common reference impedances and the corresponding offset values. The following equation can be used to calculate the offset for impedances not listed in Table 2-5:

$$\text{Offset (for dBm)} = 10 \log \frac{\text{New ref } Z}{600\Omega}$$

To make dBm measurements referenced to another impedance, proceed as follows:

- A. Choose the desired reference impedance.
- B. Calculate or look up the offset value in Table 2-5 for the desired reference impedance.
- C. Determine dBm at the desired reference impedance as follows:

$$\text{dBm (at ref } Z) = 175 \text{ reading} - \text{offset}$$

Example: Make dBm measurements references to a 100Ω reference impedance.

Table 2-3. dB Specifications for DC Volts (600Ω Ref).

Linear Counts	Resolution	Accuracy
10 - 99	1 dBm	± 1 dBm
100 - 999	0.1 dBm	± 0.1 dBm
1000 - 20000	0.01dBm	± 0.02 dBm

Table 2-4. dB Specifications for AC Volts (600Ω Ref)

dB Mode (ref: 600Ω)		Accuracy (\pm dBm)			
Range	Input	20Hz-10kHz	10kHz-20kHz	20kHz-50kHz	50kHz-100kHz
200mV	1mV to 2mV (-58 to -52dBm)	2*	—	—	—
	2mV to 20mV (-52 to -32dBm)	2	3	—	—
2V-750V	20mV to 200mV (-32 to -12dBm)	0.2	03.	1	—
	200mV to 750V (-12 to +59.8dBm)	0.2	0.26	0.56	1.2

*Up to 1kHz

- i. 100Ω is not listed in Table 2-5 so the offset must be calculated as follows:

$$\text{Offset} = 10 \log\left(\frac{100\Omega}{600\Omega}\right)$$

$$\text{offset} = -7.78\text{dB}$$

- ii. Subtract -7.78dB from all subsequent displayed readings on the Model 175,

dBm measurements, referenced to another impedance, can be read directly from the display of the Model 175 by utilizing the REL feature, and an accurate voltage source. The basic procedure is as follows:

- A. Calculate or look up the equivalent voltage level (Table 2-5) for 0dBm at the desired reference impedance.
 - B. Input that voltage level to the Model 175.
 - C. With the Model 175 in the dB mode, press the REL button.
 - D. dBm measurements referenced to the desired impedance can now be read directly from the display of the Model 175.
3. dBW Measurements
- dBW is defined as decibels above or below a one watt reference. The procedure is the same as that found in paragraph 2.7.8 step 2. The only difference is that the reference point is 0dBW (1W) rather than 0dBm (1mW).
4. dBV Measurements
- dBV is defined as decibels above or below 1V (0dBV point). This is a voltage relationship independent of impedance. The basic procedure is to simply subtract 2.22 dB (Table 2-5) from all subsequent displayed readings on the Model 175..
5. Relative dB Measurements

Just about any voltage level within the measurement limits of the Model 175 can be established as the 0dB point. The basic procedure is to establish that level as the 0dB point by using REL and make the desired dB measurements.

Table 2-5. Levels for Other Reference Impedances

Reference Impedance (Ω)	Equiv. Voltage Level for:		Offset (6000 Ref)	
	0dBm	0dBW	0dBm	0dBW
8	0.0894	2.828	-18.75	11.25
50	0.2236		-10.79	
75	0.2739		- 9.03	
150	0.3873		- 6.02	
300	0.5477		- 3.01	
600	0.7746		0.00	
1000	1 .0000		2.22	

$$V_{\text{equiv. for 0dBm}} = \sqrt{10^{-3}\text{W} \cdot Z_{\text{REF}}}$$

$$V_{\text{equiv. for 0dBW}} = \sqrt{Z_{\text{REF}}}$$

$$\text{Offset (for dBm)} = 10 \log\left(\frac{Z_{\text{REF}}}{600\Omega}\right)$$

$$\text{Offset (for dBW)} = 10 \log\left(\frac{Z_{\text{REF}}}{600\Omega \cdot .001}\right)$$

2.7.9 dB Measurement Considerations and Applications

1. Typical Instrument Performance

Typically, the Model 175 will perform better than its published dB specification, The following example will illustrate this point:

- A. Using the Model 175 in the dB mode (**600 Ω** ref) measure a 1mV RMS, 1kHz source (common application in the communications field). Typically, the Model 175 will read -57.7dBm.
- B. The calculated dBm level for that source is -57.8dBm.
- C. The O.ldBm error is considerably better than the ± 2 dBm specification. The specifications are intended to cover worst measurement conditions.

2. Measuring Circuit Gain/ Loss

Any point in a circuit can be established as the 0dB point. Measurements in that circuit are then referenced to that point expressed in terms of gain (+ dB) or loss (-dB). To set the 0dB point:

- A. Place the Model 175 in volts, autorange and dB.
- B. Connect the Model 175 to the desired location in the circuit.
- C. Press the REL button. The display will read 0dB.
- D. Gain/Loss measurements can now be made referenced to the 0dB point.

3. Measuring Bandwidth

The Model 175 can be used to determine the bandwidth of an amplifier as follows:

- A. Connect a signal generator to the input of the amplifier.
- B. Set the Model 175 to ACV and autorange.
- C. Connect the DMM and a frequency counter to the load of the amplifier.
- D. Adjust the frequency of the signal generator until a peak AC voltage reading is measured on the Model 175.
- E. Press the dB button and then press the REL button. The 0dB point is now established.
- F. Increase the frequency input until the Model 175 reads -3.00dB. The frequency measured on the frequency counter is the high end limit of the bandwidth.
- G. Decrease the frequency input until the dB reading again falls to -3dB. The frequency measured on the signal generator is the low end limit of the bandwidth.

4. Determining Q

The Q of a tuned circuit can be determined as follows:

- A. Determine the center frequency and bandwidth as explained in paragraph 2.7.9 step 3.
- B. Calculate Q by using the following formula:

$$Q = \text{Center Frequency} / \text{Bandwidth}$$

2.7.10 MIN/MAX and 100 Point Data Logger Operation

The data logger can store up to 100 readings and store the minimum and maximum readings recorded during the period that the data logger is active. The Data Logger remains active even after 100 points of data are stored, which means the MIN/MAX readings continue to update. The only way to deactivate the Data Logger is to press the STO/CLR button (STO annunciator off) or cycle power. The 100 points of data are stored at one of six selectable rates from three per second to one reading per hour. Readings for minimum and maximum are sampled at the rate of three per second regardless of the selected rate. The procedure for operating the data logger is as follows:

1. Connect the desired measurement configuration to the Model 175. Make sure that the controls of the Model 175 are set appropriately.
2. Logging Data:
 - A. Press and hold the STO/CLR pushbutton. The following reading rates will scroll on the display:
 - r = 0 (every reading)
 - r = 1 (1 rdg/sec)
 - r = 2 (1 rdg/10 sec)
 - r = 3 (1 rdg/min)
 - r = 4 (1 rdg/10 min)
 - r = 5 (1 rdg/hr)

NOTE

There is no need to select a rate if just minimum/maximum readings are desired. Momentarily press the STO/CLR button to start the logger.

- B. Release the STO/CLR pushbutton when the desired reading rate is displayed. The STO annunciator will turn on and data will be logged at the selected rate.

NOTE

The logging cycle can be terminated at any time by pressing the STO/CLR button. This shuts off the data logger. However, data is retained and can be recalled at any time as long as the instrument remains on.

3. Data Retrieval

Data can be retrieved at any time, but a flashing RCL annunciator indicates that the maximum number of readings (100) have been stored.

- A. Press and hold in the RCL pushbutton. The display will scroll through the data points and MIN/MAX (LO/HI). The first data point displayed will be the last stored reading. The next two data points will be the HI and LO readings made during that logging cycle. Notice that the longer the RCL pushbutton is held in the faster the data points will scroll on the display.
 - B. Release the RCL pushbutton at the desired data point and note the reading (data) on the display. The data pointer can be incremented by steps of one by momentarily holding in the RCL pushbutton.
 4. Shut off the data logger by pressing the STO/CLR pushbutton. All stored data will be retained until a new store cycle has commenced.

2.7.11 Diode Test

The 2k Ω and 200k Ω ranges can be used for testing semiconductor junctions as follows:

1. Select Ω function.
2. Press 2k and 200k pushbuttons (diode symbols) in simultaneously.
3. Display reads forward V drop of diode at 0.7mA (up to 2V). Red terminal is positive.

2.8 TRMS CONSIDERATIONS

Most DMMs actually measure the average value of an input waveform but are calibrated to read its RMS equivalent. This poses no problems as long as the waveform being measured is a pure, low-distortion sine wave. For complex, non-sinusoidal waveforms, however, measurements made with an averaging type meter can be grossly inaccurate. Because of its TRMS (True Root Mean Square) measuring capabilities, the Model 175 provides accurate AC measurements for a wide variety of AC input waveforms

2.8.1 AC Voltage Offset

Typically the Model 175 will display 25 counts or less of offset on AC volts with the input shorted. This offset is caused by amplifier noise and offset of the TRMS converter. This offset will not affect reading accuracy and should not be zeroed out using the REL feature. The following equation expresses how this offset (V_{OFFSET}) is added to the signal input (V_{IN}):

$$\text{Displayed reading} = \sqrt{(V_{\text{IN}})^2 + (V_{\text{OFFSET}})^2}$$

As long as V_{IN} is at least 10 times larger than V_{OFFSET} , negligible error will occur.

Example: Range = 2VAC range
Offset = 25 counts
Input = 200mV RMS

$$\begin{aligned} \text{Displayed Reading} &= \sqrt{(0.2)^2 + (.0025)^2} \\ &= \sqrt{0.04 + 0.000063} \\ &= \sqrt{0.040063} \\ &= .2000V \text{ RMS} \end{aligned}$$

If REL is used to zero the display, the 25 counts of offset would be subtracted from V_{IN} resulting in an error of 25 counts in the displayed reading.

2.8.2 TRMS Measurement Comparison

The RMS value of a pure sine wave is equal to 0.707 times its peak value. The average value of such a waveform is 0.637 times the peak value. Thus, for an average-responding meter, a correction factor must be designed in. This correction factor, K, can be found by dividing the RMS value by the average value as follows:

$$K = \frac{0.707}{0.637} = 1.11$$

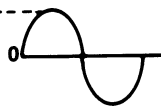
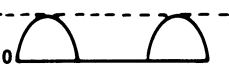

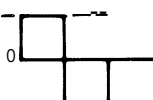
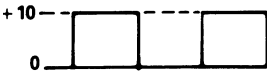
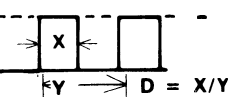
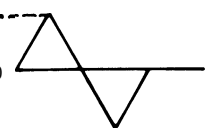
By applying this correction factor to an averaged reading, a typical meter can be designed to give the RMS equivalent. This works fine as long as the waveform is a pure sine wave, but the ratios between the RMS and average values of different waveforms is far from constant, and can vary considerably.

Table 2-6 shows a comparison of common types of waveforms. For reference, the first waveform is an ordinary sine wave with a peak altitude of 10V. The average value of this voltage is 6.37V, while its RMS value is 7.07V. If we apply the 1.11 correction factor to the average reading, it can be seen that both meters will give the same reading, resulting in no error in the average-type meter reading.

The situation changes with the half-wave rectified sine wave. As before, the peak value of the waveform is 10V, but the average value drops to 3.18V. The RMS value of this waveform is 3.86V, but the average responding meter will give a reading of 3.53V (3.18×1.11), creating an error of 11%.

A similar situation exists for the rectified square wave, which has an average value of 5V and an RMS value of 7.07V. Here, the average responding meter gives a reading of 5.55V (5×1.11), while the Model 175 gives a TRMS reading of 5V. Other waveform comparisons can be found in Table 6-2.

Table 2-6. Comparison of Average and TRMS Meter Readings

Waveform	Peak Value	RMS Value	Average Responding Meter Reading	AC Coupled TRMS Meter Reading	Averaging Meter Percent Error
Sine +10 0 	10V	7.07V	7.07V	7.07V	0%
Half-Wave Sine +10 0 	10V	3.86V	3.53V	3.86V	8.5%
Full-Wave Sine +10 0 	10V	3.08V	2.98V	3.08V	3.2%
Square +10 0 	10V	10.00V	11.10V	10.00V	11%
Rectified Square Wave +10 0 	10V	5.00V	5.55V	5.00V	11%
Rectangular Pulse 10 0  $D = X/Y$ $K = D \cdot D^2$	10V	10K	11.1K	10K	11%
Triangular Sawtooth 10 0 	10V	5.77V	5.54V	5.77V	4%

2.8.3 Crest Factor

The crest factor of a waveform is the ratio of its peak value to its RMS value. Thus, the crest factor specifies the dynamic range of a TRMS instrument. For sinusoidal waveforms, the crest factor is 1.414. For a symmetrical square wave, the crest factor is unity.

The crest factor of other waveforms will, of course, depend on the waveform in question because the ratio of peak to RMS value will vary. For example, the crest factor of a rec-

tangular pulse is related to its duty cycle; as the duty cycle decreases, the crest factor increases. The Model 175 has a crest factor of 3, which means the instrument will give accurate TRMS measurements of rectangular waveforms with duty cycles as low as 10%.

2.8.4 Extended Frequency Response

Figure 2-7 illustrates the extended frequency response of the AC volts ranges up to 1MHz.

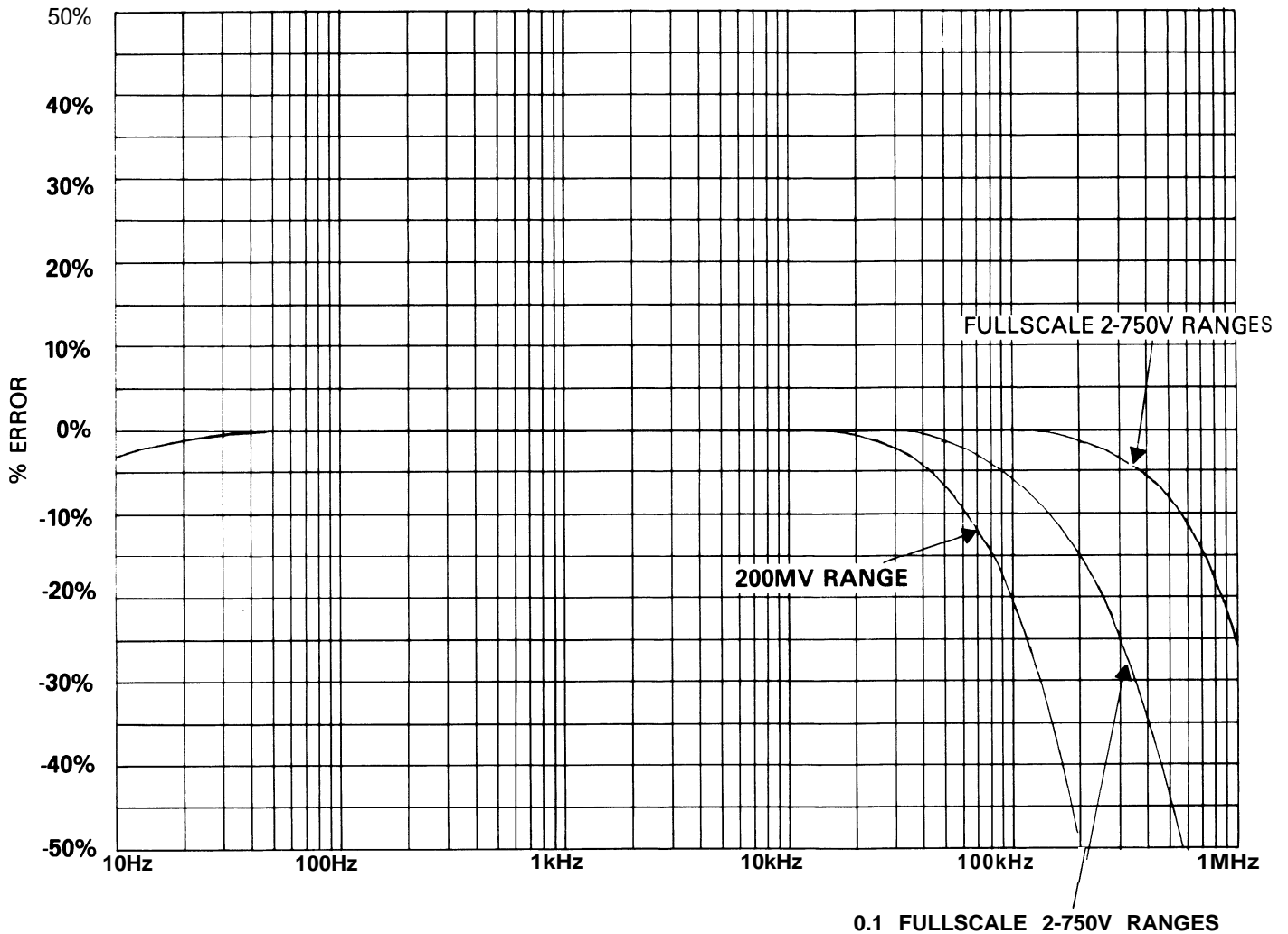


Figure 2-7. Model 175 Typical ACV Frequency Response