INSTRUCTION MANUAL

Digital Multimeter

Model 179/179-20A

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DC VOLTAGE

RANGE	MAXIMUM READING	ACCURACY (12 months) 18°-28°C ±(% rdg + digits)	MAXIMUM ALLOWABLE INPUT
200mV	199.99	0.04% + 3d	1200V momentary
2 V	1.9999	0.04% + 1d	1200V momentary
20 V	19.999	0.04% + 1d	1200V
200 V	199.99	0.04% + 1d	1200V
1200 V	1200.0	0.04% + 1d	1200V

Temperature Coefficient (0°-18° and 28°-55°C):
±(0.006% + 0.2 digit)/°C except ±(0.006% + 0.4 digit)/°C on the 200mV range.
Input Resistance: 10MΩ ±0.1%

Normal Mode Rejection Ratio:
Greater than 60dB at 50Hz and 60Hz.
Common Mode Rejection Ratio (1kΩ unbalance):
Greater than 120dB at DC, 50Hz and 60Hz.
Settling Time: 1 second to within 1 digit of final reading

AC VOLTAGE

RANGE	MAXIMUM READING	ACCURACY (12 months) (above 2000 counts) 18°-28°C; 100Hz-10kHz ±(% rdg + digits)	TEMPERATURE COEFFICIENT 0°-18° and 28°-55°C ±(% rdg + digits)/°C 45Hz-10kHz	10kHz-20kHz
200mV	199.99	0.7% + 15d	0.07% + 2d	0.15% + 3d
2 V	1.9999	0.6% + 15d	0.07% + 2d	0.15% + 3d
20 V	19.999	0.5% + 15d	0.05% + 2d	0.05% + 2d
200 V	199.99	0.5% + 15d	0.05% + 2d	0.05% + 2d
1000 V	1000.0	0.5% + 15d	0.05% + 2d	0.05% + 2d

Extended Frequency Accuracy:
-(45Hz-100Hz) ±(0.7% + 15 digits)
(10kHz-20kHz) ±(0.8% + 15 digits) on the 20V and higher ranges, ±(1.5% + 15 digits) on the 2V range, ±(2% + 15 digits) on the 200mV range.
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, 10^7V•Hz maximum.
Common Mode Rejection Ratio (1kΩ unbalance):
60dB at DC, 50Hz and 60Hz.
Settling Time: 2.5 seconds to within 10 digits of final reading.

DC AND TRMS AC CURRENT

RANGE	MAXIMUM READING	ACCURACY (12 months) 18°-28°C ±(% rdg + digits) DC	AC 45Hz-10kHz (above 2000 counts)	MAXIMUM VOLTAGE BURDEN	SHUNT RESISTANCE
200μA	199.99	0.2% + 2d	1% + 15d	0.2 V	1kΩ
2mA	1.9999	0.2% + 2d	1% + 15d	0.2 V	100 Ω
20mA	19.999	0.2% + 2d	1% + 15d	0.2 V	10 Ω
200mA	199.99	0.2% + 2d	1% + 15d	0.25V	1 Ω
2000mA	1999.9	0.2% + 2d	1% + 15d	0.6 V	0.1 Ω
20 A**	19.999	0.5% + 2d	1% + 15d* (1kHz max)	0.65V	0.01 Ω

*Add 0.1% rdg above 15A for self-heating.
**20A range on Model 179-20A only.

MAXIMUM INPUT: 2A, 250V DC or rms (fuse protected) except for 20A range.
15A continuous, 20A for 1 minute (50% duty cycle).
250V dc or rms (fuse protected) on 20A range.

Temperature Coefficient (0°-18° and 28°-55°C):
DC ± (0.01% + 0.2 digits)/°C.
AC ± (0.07% + 2 digits)/°C.
Crest Factor: 3
Settling Time: DC: 1 second to within 1 digit of final reading.
AC: 2.5 seconds to within 10 digits of final reading.

RESISTANCE

RANGE	MAXIMUM READING	ACCURACY (12 months) 18°-28°C ±(% rdg + digits) HI Ω	LO Ω	MAXIMUM VOLTAGE ACROSS UNKNOWN ON RANGE HI Ω	LO Ω	TEMPERATURE COEFFICIENT 0°-18° and 28°-55°C ±(% rdg + digits)/°C HI Ω	LO Ω	NOMINAL APPLIED CURRENT HI Ω	LO Ω
2 kΩ	1.9999	–	0.15% + 15d	–	0.2V	–	0.02% + 2d	–	100μA
20 kΩ	19.999	0.04% + 1d	0.15% + 15d	2V	0.2V	0.003% + 0.2d	0.02% + 2d	100μA	10μA
200 kΩ	199.99	0.04% + 1d	0.15% + 15d	2V	0.2V	0.003% + 0.2d	0.02% + 2d	10μA	1μA
2000 kΩ	1999.9	0.04% + 1d	0.15% + 15d	2V	0.2V	0.003% + 0.2d	0.03% + 2d	1μA	0.1μA
20MΩ	19.999	0.10% + 1d	–	2V	–	0.02 % + 0.2d	–	0.1μA	–

Maximum Allowable Input:
450V rms sustained, 1kV DC or peak AC momentary.
Maximum Open-Circuit Voltage: 5 volts.

Settling Time: 1 second to within 1 digit of final reading except 2 seconds on the 20MΩ range.

GENERAL

DISPLAY: Five 0.5" LED digits, appropriate decimal position and polarity indication.
CONVERSION PERIOD: 400 milliseconds.
ENVIRONMENT:
Operating: 0°C to 55°C.
0% to 80% relative humidity up to 40°C.
Storage: -25°C to +65°C.

POWER: 105-125 or 210-250 volts (switch selected), 90-110V available. 50-60Hz, 7 watts. Optional 6 hour battery pack, Model 1788.
DIMENSIONS, WEIGHT: 85mm high x 235mm wide x 275mm deep (3-1/2 in. x 9-1/4 in. x 10-3/4 in.)
Net weight: 1,7kg. (3 lbs. 13 oz)
OVERRANGE INDICATION: Display blinks all zeros above 19999 counts
MAXIMUM COMMON MODE VOLTAGE: 1400V peak

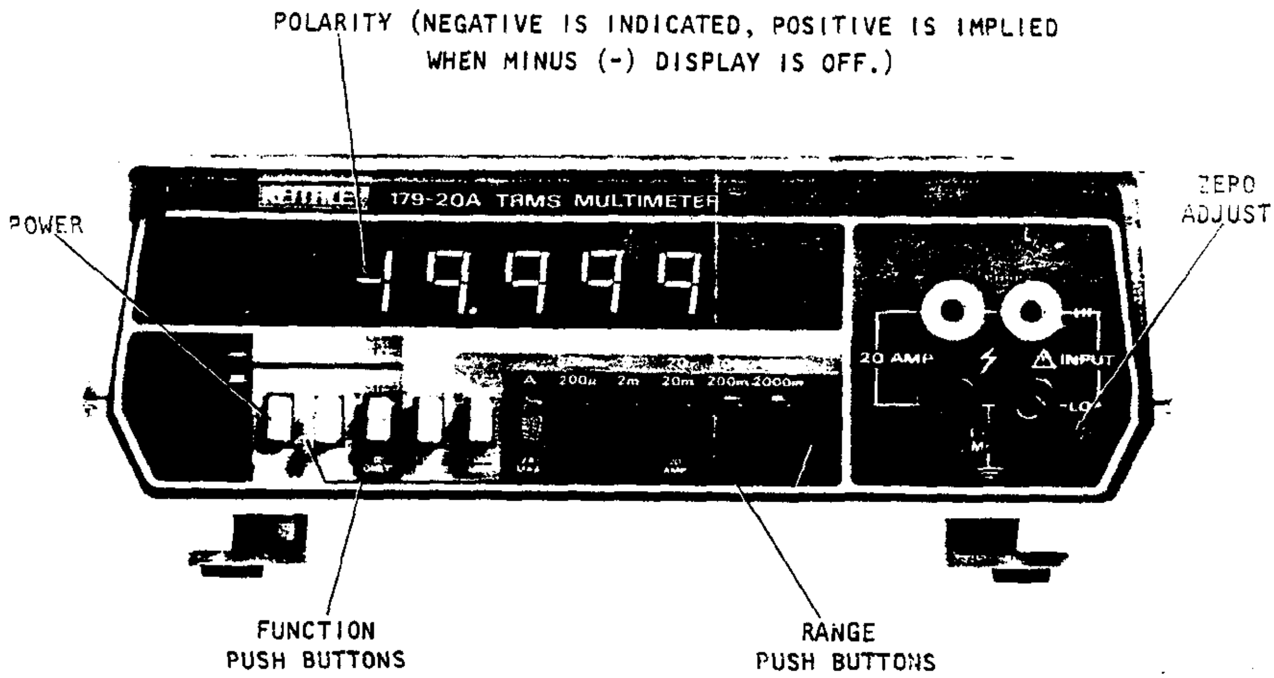


FIGURE 1-1. Front Panel.

SECTION 1. GENERAL INFORMATION.

1-1. INTRODUCTION. The Models 179 and 179-20A are versatile digital multimeters useful for measurement of ac and dc voltage, ac and dc current and resistance. The Model 179-20A is identical to the Model 179, except for an added 20-ampere range. This extra range uses separate input terminals and allows continuous measurement of up to 15A ac/dc, or intermittant duty measurements up to 20A ac/dc. The Model 179-20A is treated by the exception method in this manual. That is, information headed by Model 179-20A applies only to the Model 179-20A. Information headed by Model 179 is common to both the Model 179 and the Model 179-20A. Ranges and accuracies for both models are listed in the Table of Specifications on page v. Ranges and functions are selected with front panel pushbuttons. The decimal point is also positioned by the selected range pushbutton. Polarity of the measured signal is automatically displayed.

1-2. WARRANTY INFORMATION. The Warranty is given on the inside front cover of this Instruction Manual. If there is a need to exercise the Warranty, contact the Keithley Representative in your area to determine the proper action to be taken. Keithley maintains service facilities in the United Kingdom and West Germany, as well as in the United States. Check the inside front cover of the Instruction Manual for addresses.

1-3. CHANGE NOTICES. Improvements or changes to the instrument which occur after printing of the Instruction Manual will be explained on a Change Notice sheet attached to the inside back cover.

IMPORTANT

The ⚠ symbol can be found in various places in this Instruction Manual. Carefully read the associated CAUTION statements with regard to proper use and handling of the instrument. Damage to the instrument may occur if these precautions are ignored.

The ⚡ symbol can be found in various places in this Instruction Manual. This symbol indicates those areas on the instrument which are potential shock hazards. Carefully read the associated WARNING statements with regard to proper use and handling of the instrument. Serious personal injury may result if these precautions are ignored.

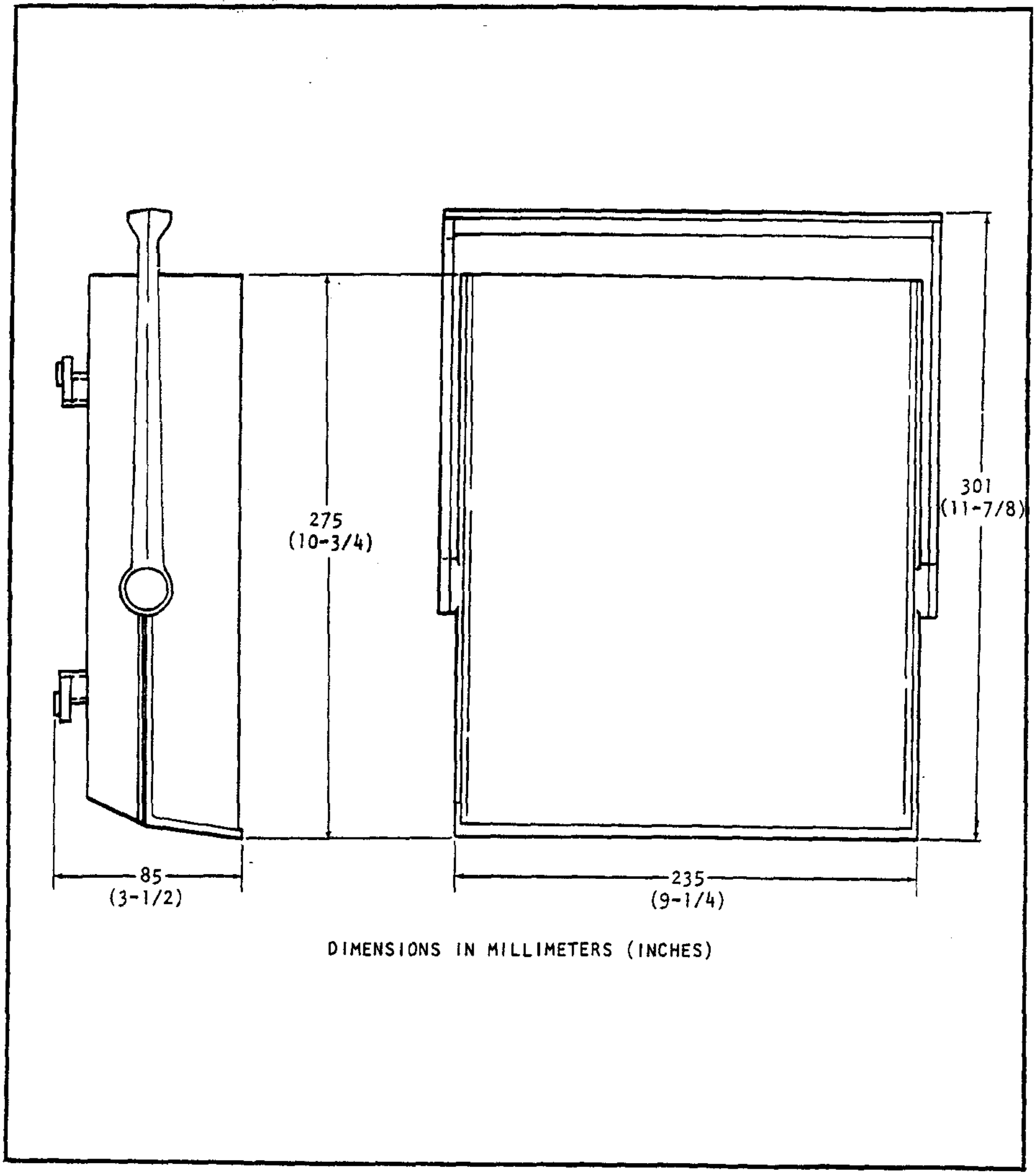


FIGURE 1-2. Dimensional Data

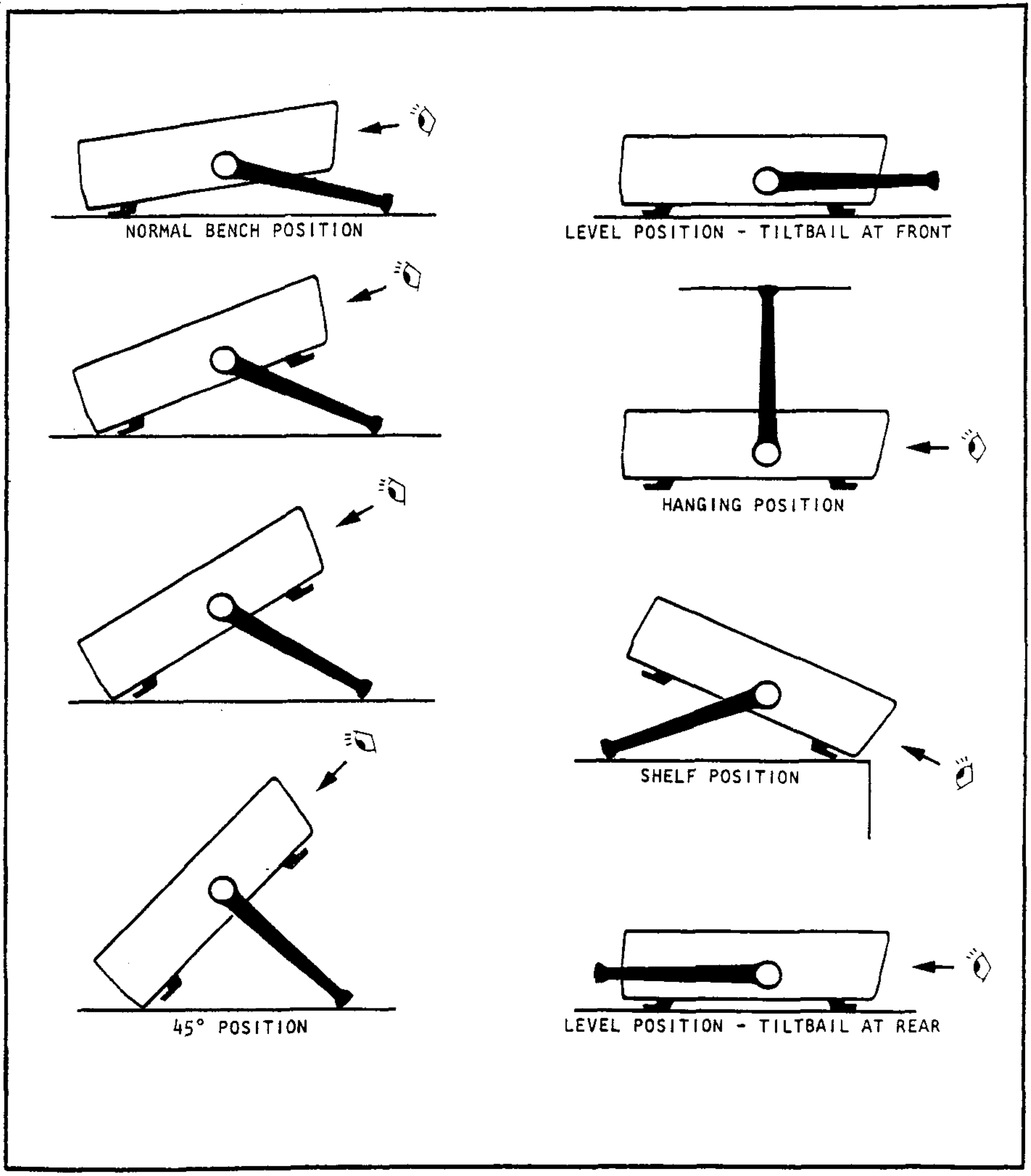


FIGURE 1-3. Tilt Bail Positions.

SECTION 2. OPERATION.

2-1. GENERAL. This section provides information needed for incoming inspection and preparation for use.

2-2. INSPECTION. The Model 179 was carefully inspected both mechanically and electrically before shipment. Upon receiving the instrument, check for any obvious damage which may have occurred during transit. Report any damages to the shipping agent. To verify the electrical specifications, follow the procedures given in Section 3.

2-3. PREPARATION FOR USE. The Model 179 is shipped ready-to-use. The instrument may be powered from line voltage or from rechargeable batteries (when the optional Model 1788 Rechargeable Battery Set is installed).

2-4. OPERATION ON LINE POWER. The Model 179 DMM is provided with 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.

a. Set the LINE VOLTAGE switch on the back of the instrument to correspond to the line voltage available. Ranges are 105 to 125 volts and 210 to 250 volts ac as shown in Figure 2-1.

WARNING

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

b. Plug the power cord into a properly grounded outlet. Operate the 179 DMM as described in SECTION 2-7.

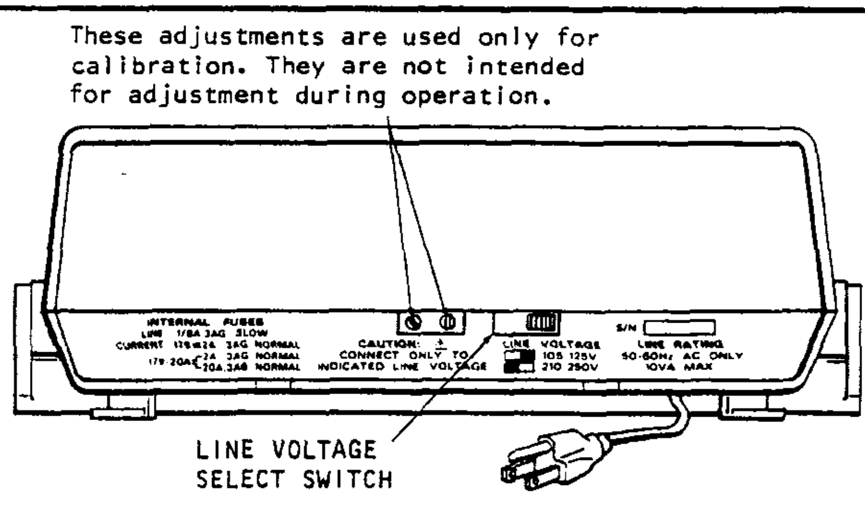


FIGURE 2-1. Rear View Showing Line Switch.

2-5. OPERATION ON BATTERY PACK POWER. The Model 179 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 179 DMM for up to 6 hours. Circuits within the battery pack will automatically shut down the instrument when the battery charge is insufficient to maintain accurate readings. Refer to Figure 2-2 and install the battery pack as follows:

WARNING

Disconnect the line cord before removing the case cover.

a. Turn off the power and disconnect the line cord. Remove four screws from the bottom of the case and separate the top cover from the bottom cover.

b. Lift off the calibration shield, and save it for later use. The four plastic spacers must remain in place on the upright studs projecting through the main circuit board.

NOTE

Do not discard the calibration shield. This shield must be installed during calibration, as described in Section 4.

c. Set the BAT/LINE switch to the BAT position shown in Figure 2-2. Note that the battery pack will not operate properly if this switch is not in the BAT position.

d. Remove fuse F301 on the battery pack.

e. Install the battery pack in the instrument so that it rests on the plastic spacers. The ground clip must make contact with the upper side of the battery pack plate.

f. Carefully align the battery pack plug with connector P1004 on the circuit board. Push the plug firmly onto the connector until the lip on the plug engages the lip on the connector to lock the plug in place.

CAUTION

Make sure the connector is aligned so that all pins mate properly, otherwise, damage to the DMM will result.

g. Install fuse F301. Reinstall top cover and secure with four screws.

h. Charge the battery pack as described in Paragraph 2-6.

2-6. BATTERY CHARGING. The Model 1788 Battery Pack contains an integral battery charger. To charge or recharge the battery pack, install the battery pack in the 179 DMM as described above and proceed as follows:

a. Connect the instrument to line power as described in Paragraph 2-4.

b. 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.

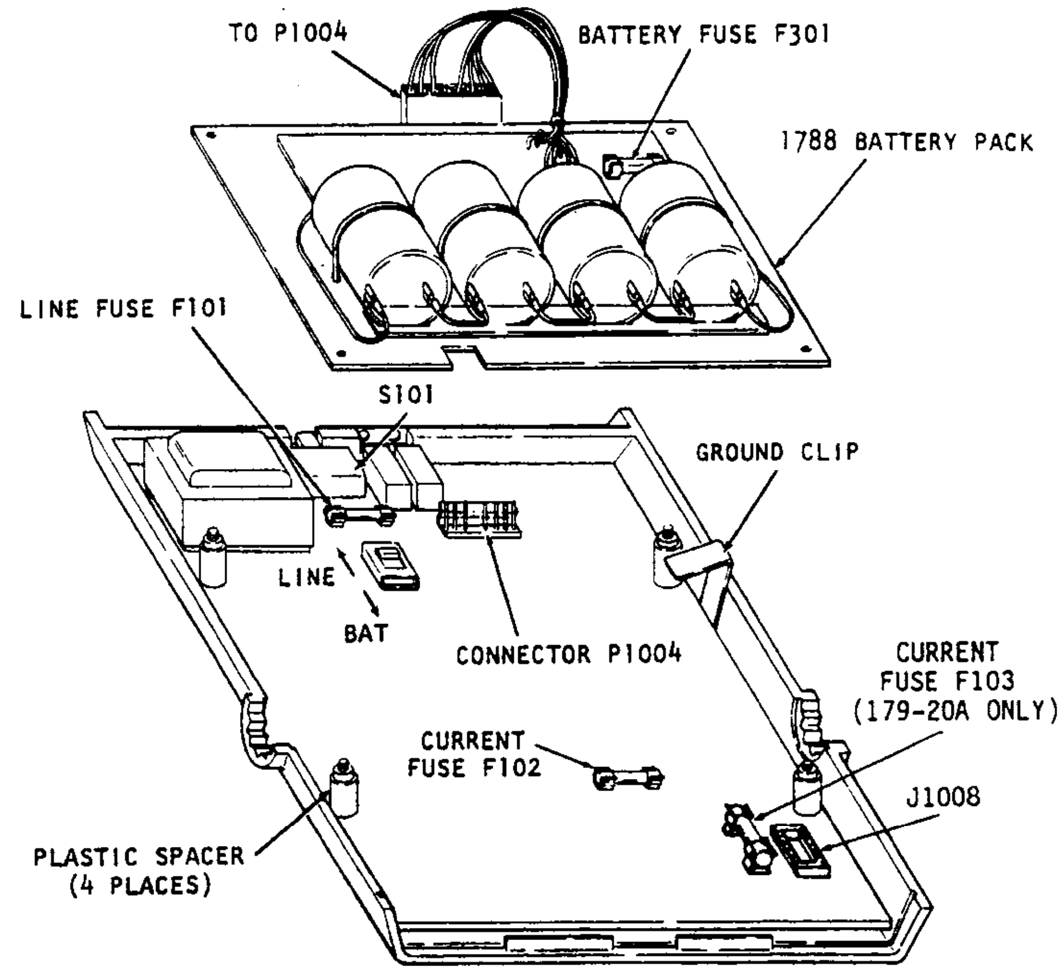


FIGURE 2-2. Battery Pack Installation

c. When the 179 DMM is in use on line power, the battery charger maintains a trickle charge on the battery pack.

2-7. OPERATING INSTRUCTIONS. Refer to Figure 2-3 and operate the DMM as follows:

a. Turn on the power by depressing the ON/OFF pushbutton.

b. Select the function with the AC/DC, Ω, V, or A pushbuttons.

c. Select the range by depressing the appropriate pushbutton. For resistance measurements only, also set the LO/HI pushbutton as desired.

d. Connect the source to the INPUT terminals. Accessories described in Paragraph 2-14 should be used as required.

CAUTION

MAXIMUM RATINGS: ⚠

DCV (200mV, 2V): 450V rms continuous; 1200V peak, for 8 seconds per minute.
(20-1200V): 1200V peak.

ACV (All Ranges): 1000V rms; 1400V peak; 10^7V•Hz.

DCA,ACA (200µA-2000mA): 2A, 250V DC or rms (fuse protected)
(20A): 15A continous, 20A for 1 minute (50% duty cycle), 250V dc or rms (fuse protected)

Ω (All Ranges): 450V rms sine wave; 1000V peak, for 8 seconds per minute.

2-8. DC VOLTAGE MEASUREMENT. Use the Model 179 DMM to measure dc volts as follows:

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

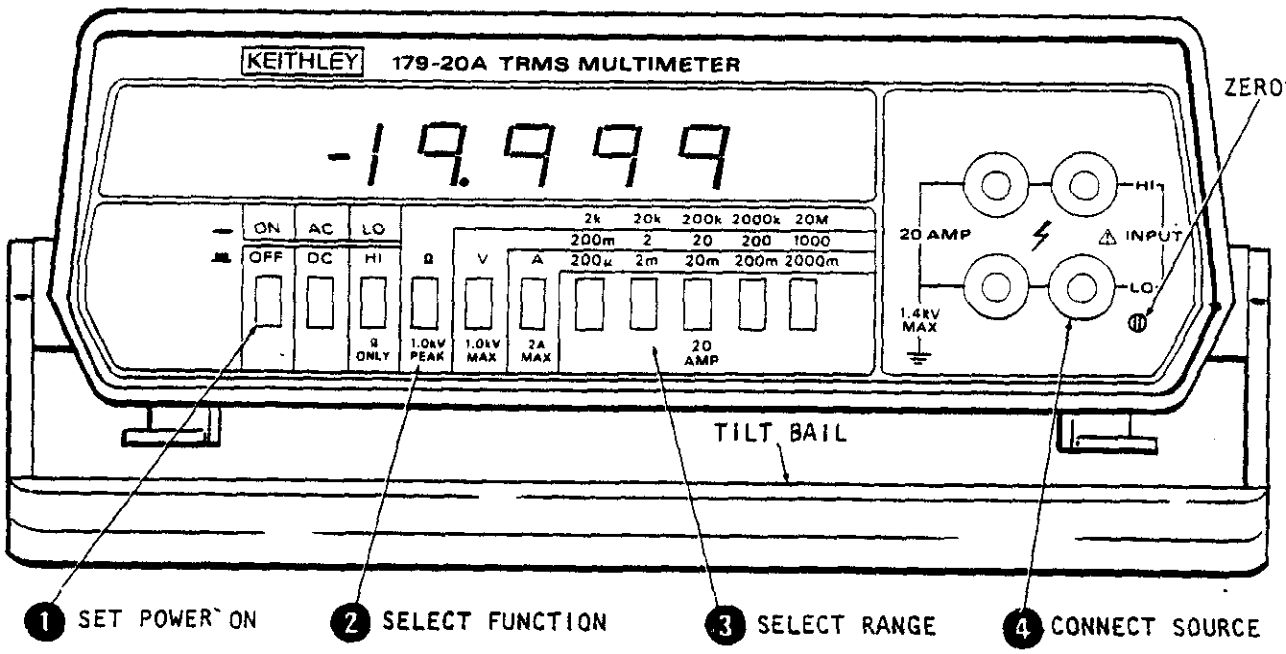
b. Select the desired range from the five ranges available. The maximum reading is 19999. Overrange is indicated by a flashing 0000 except on the 1000 volt range.

CAUTION

⚠ Do not exceed the maximum ratings. Instrument damage may occur.

c. Negative polarity is displayed automatically. Positive polarity is implied when the minus (-) display is off.

d. Zero the instrument as described in Paragraph 2-14, before the first use whenever the instrument is used outside the temperature range of 18° to 28°C, and approximately weekly during normal use.



*Adjust zero as required for measurement of dc volts and resistance. See text.

FIGURE 2-3. Operating Controls.

2-9. AC VOLTAGE MEASUREMENT. Use the Model 179 DMM to measure ac volts as follows:

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

CAUTION

⚠ Do not exceed the maximum ratings. Instrument damage may occur.

b. Select the desired range from the five ranges available. The maximum reading is 19999. Overrange is indicated by a flashing 0000 except on the 1000 volt range. The instrument measures the true root mean square of a signal within the frequency range of 45 to 20k hertz. Maximum crest factor for rated accuracy is 3.

c. The Model 1682 RF Probe (see Paragraph 2-15) should be used to measure ac voltages with a frequency of 20k to 100M hertz.

d. Refer to Paragraph 2-13 for TRMS measurements of a signal with both ac and dc components.

2-10. RESISTANCE (Ω) MEASUREMENT. Use the 179 DMM to measure resistance as follows:

a. Turn on power and depress the Ω pushbutton.

CAUTION

⚠ Do not exceed the maximum ratings. Instrument damage may occur.

b. Select the desired range from the five ranges available. The maximum reading is 19999. Overrange is indicated by a flashing 0000. Use the LO/HI pushbutton as follows:

1) Use the HI mode for measurements in the 20k, 200k, 2000k and 20M ohm ranges. Full range voltage drop is 2 volts and is sufficient to cause forward conduction of semiconductor junctions. The HI terminal is positive.

2) Use the LO mode for measurements in the 2k, 20k, 200k and 2000k ohm ranges. Full range voltage drop is 200 millivolts. Depressing 2k automatically selects LO mode; 20M selects HI mode. Maximum open circuit voltage is 5V on all ranges.

c. Zero the instrument as described in Paragraph 2-14 before the first use whenever the instrument is used outside the temperature range of 18° to 28°C, and approximately weekly during normal use.

2-11. CURRENT MEASUREMENT (AC or DC). Use the Model 179 or 179-20A to measure ac or dc as follows:

NOTE

To prevent measurement errors when using the Model 179-20A, connect the current test leads to either the 20A jacks or the normal INPUT jacks. Disconnect all circuits from the unused jacks.

a. Turn on power and set the AC/DC pushbutton to the desired AC or DC position. Depress the A pushbutton.

CAUTION

⚠ Do not install larger capacity fuses than those supplied. F102 (2A) and F103 (20A, supplied with Model 179-20A only) protect the instrument against overcurrent. Normal acting fuses are used.

b. Select the desired range from the five/six ranges available. (On the Model 179-20A, the 20mA/20A pushbutton selects the 20mA range for the normal INPUT jacks and the 20A range for the 20A jacks). Connect the source to the INPUT jacks for current measurements up to 2000mA. (For current measurements between 2000mA and 20A, connect the source to the 20A jacks on the Model 179-20A). The maximum reading is 19999. Overrange is indicated by a flashing 0000. Overload is fuse protected. When using the 20A current range of the Model 179-20A, up to 15A may be applied continuously without degradation of the measurement due to self-heating effects. For currents between 15A and 20A, specified accuracy can only be obtained when measurements are limited to a 50% duty cycle (i.e., apply the current for a maximum of one minute and then allow at least one minute for cooling before making the next measurement).

2-12. TRMS MEASUREMENT. The Model 179 measures the ac component of a waveform and does not measure the dc component. For ac + dc measurements, use the procedure discussed in a. below.

NOTE

Accuracy is specified for 2000 counts and above. The method of calibrating the converter may yield an offset up to 50 digits with the input shorted. This does not affect the instrument accuracy.

a. Use the 179 DMM to measure TRMS on a signal which has both ac and dc components as follows:

1. Turn on the power. Measure and record the ac and dc components separately.
2. Compute the rms value from the following equation:

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

b. The crest factor (CF) is the ratio of the peak voltage to the rms voltage as follows:

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

1. Typical crest factors are as follows:

Sine wave	$CF = \sqrt{2}$
Square wave	$CF = 1$
Triangular wave	$CF = \sqrt{3}$
Positive pulse train (duty cycle for CF = 3 is 0.11)	$CF = 1/\sqrt{\text{duty cycle}}$

NOTE

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

2-13. ZERO ADJUSTMENT. The front panel zero adjustment nulls input offset on the 20, 200 and 1200 dc voltage ranges and on all resistance ranges. Typically, this adjustment need not be performed more often than once a week unless the instrument is operated at ambient temperatures outside the range of 18° to 28°C. Zero the instrument as follows:

a. Turn on the power and select LO Ω and the 200k range.

b. Plug in test leads and short them. Adjust the zero adjustment pot (R149) to obtain a reading of 0000 ±3 digits.

NOTE

The zero adjustment may also be used for lead compensation on a particular Ω range.

2-14. ACCESSORIES. A wide range of accessories is available to facilitate the use of the Model 179 DMM, extend its range, and adapt it for additional uses.

a. Model 1600 High Voltage Probe. The Model 1600 High Voltage Probe (shown in Figure 7) extends the measurable dc voltage range up to 40 kilovolts. It has a 1000:1 division ratio, so that a reading of 1 volt on the DMM corresponds to 1 kilovolt (1000 volts). To use the probe, select DCV and the required range, connect the high voltage probe banana plug to the instrument, connect the alligator clip to source low, and touch the probe tip to source high.

SPECIFICATIONS:

Voltage Range: 0 to 40,000 volts DC.
Input Resistance: 1000 megohms.
Division Ratio: 1000:1.
Ratio Accuracy:
±1.5% at 25kV, decreasing to
±2.0% at 20kV and 30kV,
±3.0% at 10kV and 40kV, and
±4.0% at 1kV.
Ratio Stability: ±0.01% per °C; ±0.1% per year.
Heating Effects: Self-heating due to application of high voltage for period in excess of 1 minute will cause a maximum of 0.2% additional error at 40kV (error is less at lower voltage).

WARNING

Be sure alligator clip is connected to source low before touching probe tip to source high. A shock hazard or damage to instrument may result.

b. Model 1651 50-Ampere Shunt. The Model 1651 50-Ampere Shunt (shown in Figure 2-5) permits current measurements from 0-50A dc and from 20-50A ac. The shunt has a resistance of 0.001 ohm ±1%, so that a 50-ampere current will correspond to a reading of 50 millivolts (0.0500 volt). Set the DMM to ACV or DCV and select the required range. To use the shunt, connect the leads furnished with the shunt from the shunt screw terminals to the DMM input terminals. Use separate leads (not furnished) to connect the source to the hex head bolts. Be sure to use leads with a capacity of 50 amperes, or as needed.

c. Model 1681 Clip-On Test Lead Set. This set (shown in Figure 2-5) contains two leads with banana plugs at one end and spring-action clip-on probes at the other end. Plug the leads into the DMM and attach the probes to the source.

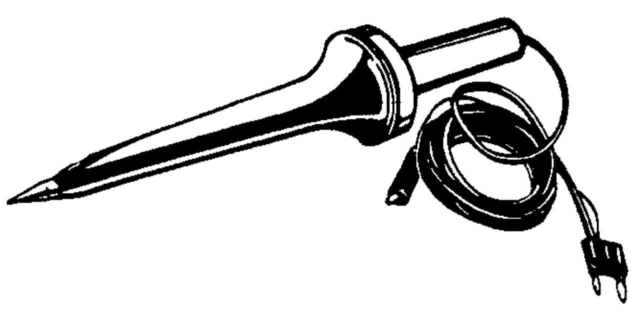


FIGURE 2-4. Model 1600 High Voltage Probe.

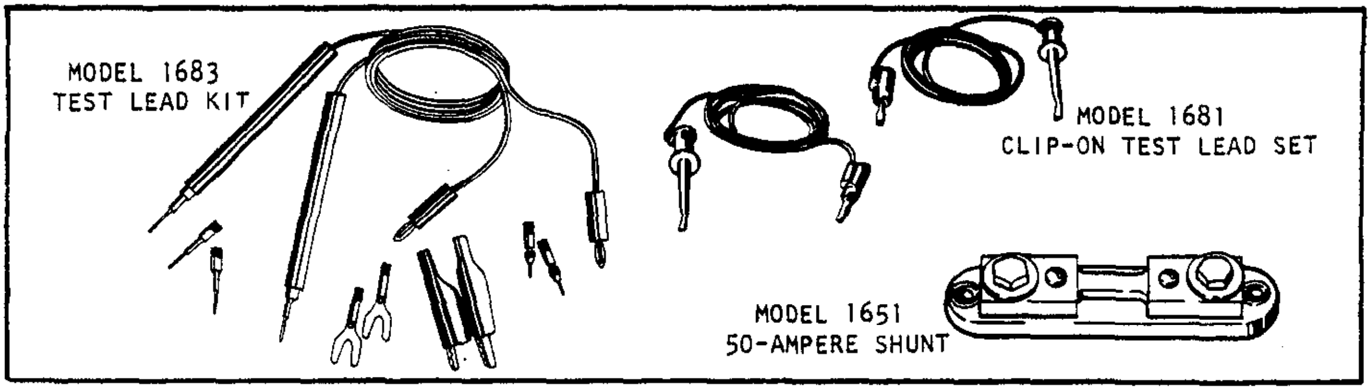


FIGURE 2-5. Accessories.

d. Model 1683 Universal Test Lead Kit. This kit (shown in Figure 2-5) contains two test leads, 14 tips, two probes, four banana plugs, two spade lugs, and two phone tips to permit connection of the DMM to virtually any source within its range.

e. Model 1682 RF Probe. The Model 1682 RF Probe (shown in Figure 2-6) permits measurement of ac voltages at frequencies of 20 kilohertz to 100 megahertz. Connect the probe to the input terminals and select ACV and the appropriate range.

SPECIFICATIONS:

Voltage Range: 0.25 to 30 volts rms.
Transfer Accuracy: ±0.5dB, 100kHz to 100MHz peak responding calibrated in rms of a sinewave.
Input Impedance: 4 megohm shunted by 3pF.
Maximum Allowable Input: 30V rms AC, 200V DC.
Accessories Supplied: straight tip, hook tip, ground clip, hi adapter, banana plug adapter.

f. Model 1685 Clamp-On AC Current Probe. The Model 1685 Clamp-On AC Current Probe (Shown in Figure 2-6) permits measurement of ac current by clamping around a single conductor, eliminating the need to interrupt the current path. Plug the ac current probe into the DMM and select ACV and the appropriate range. The DMM will display 0.1 volt rms per ampere.

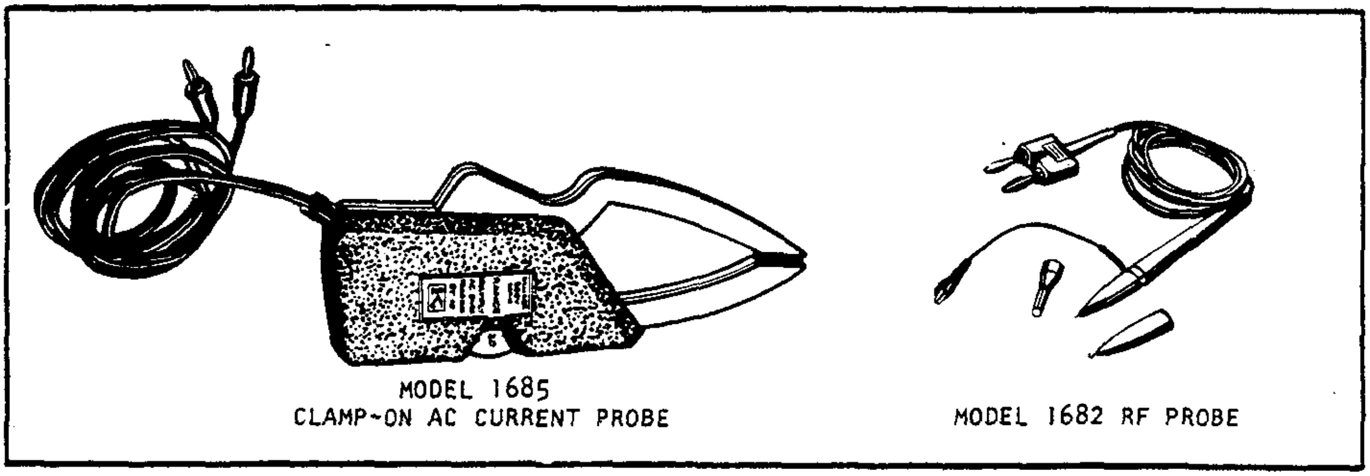


FIGURE 2-6. Model 1682 RF Probe and Model 1685 Clamp-On AC Current Probe.

SPECIFICATIONS:

Range: 2, 20 and 200 amperes rms.
Accuracy: ±4% of ranges at 60Hz. ±6% of range at 50Hz.
Temperature Coefficient: ±0.05%/°C on the 20 and 200 ampere ranges. ±0.3%/°C on the 2 ampere range.
Maximum Allowable Current: 300 amperes rms.
Maximum Conductor Voltage: 600 volts rms.
Conversion Ratio: 0.1 volt rms per ampere.

g. Model 1684 Carrying Case. The Model 1684 Carrying Case (Shown in Figure 2-7) is a hard vinyl case with a fitted foam insert to help protect the 179 DMM from damage. There is also room in the case for the service manual and other small accessories.

h. Models 1010 and 1017 Rack Mounting Kits. The rack mounting kits (shown in Figure 2-7) permit mounting one or two Model 179 DMM's in a rack for convenient viewing.

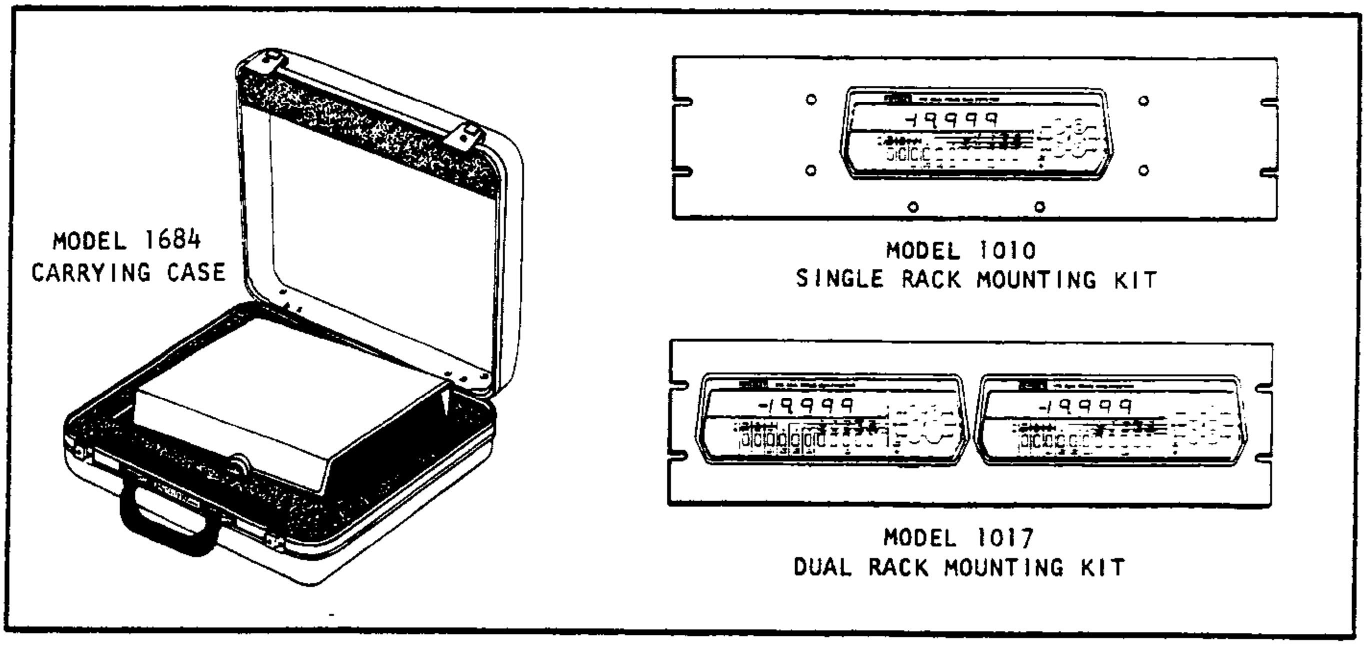


FIGURE 2-7. Carrying Case and Rack Mounting Kits.

SECTION 3. PERFORMANCE VERIFICATION.

3-1. GENERAL. Performance verification should be performed upon receipt of the instrument to ensure that no damage or misadjustment has occurred during transit. Verification may also be performed whenever there is question of the instrument's accuracy, and following calibration, if desired.

NOTE

For instruments that are still under warranty (less than 12 months since date of shipment), if the instrument's performance falls outside specifications at any point, contact your Keithley representative or the factory immediately.

3-2. RECOMMENDED TEST EQUIPMENT. Recommended test equipment for performance verification is listed in Table 3-1. Alternate test equipment may be used. However, if the accuracy of the alternate test equipment is not at least 10 times better than the instrument specifications, additional allowance must be made in the readings obtained.

3-3. ENVIRONMENTAL CONDITIONS. All measurements should be made at an ambient temperature within the range of 18° to 28°C (65° to 82°F), and a relative humidity of less than 80%.

3-4. PERFORMANCE VERIFICATION PRODECURE. Use the following procedures to verify the basic accuracy of the Model 179 DMM for voltage, resistance and current measurements. If the instrument is out of specifications at any point, perform a complete calibration as described in Section 4, unless the instrument is still under warranty, as noted above.

TABLE 3-1.
Recommended Test Equipment For Performance Verification.

ITEM	DESCRIPTION	SPECIFICATION	MFR.	MODEL
A	DC Calibrator	0.1V, 1V, 10V, 100V, 1000V ±0.002% or 20µV	Fluke	343A
B	AC Calibrator	0.1V, 1V, 10V, 100V ±0.022%	H-P	745A
C	AC Calibrator/Amplifier	1000V @ ±0.04%	H-P	745A/746A
D	Decade Resistor	1.9KΩ, 19KΩ, 190KΩ 1.9MΩ, 19MΩ, ±0.01%	ESI	RS725
E	Current Calibrator	100µA, 1mA, 10mA, 100mA, 1A, 10A, ±0.03%	VALHALLA	2500E

NOTE

Performance verification should be performed by qualified personnel using accurate and reliable test equipment.

a. Initial Conditions. Before beginning the verification procedure the instrument must meet the following conditions:

1) If the instrument has been subjected to extremes of temperature, allow internal temperatures to stabilize for one hour minimum at the environmental conditions specified in Paragraph 3-3.

2) Turn on the 179 DMM and allow it to warm up for 10 minutes. The instrument may be operated from either line power or from battery pack power, as long as the battery pack has been fully charged as described in Paragraph 2-6.

3) Zero the instrument as described in Paragraph 2-14.

WARNING

Some procedures require the use of high voltage. Take care to prevent contact with live circuits which could cause electrical shock resulting in injury or death.

b. DC Volts Checkout.

1) Select dc voltage readings with the AC/DC and V pushbuttons.

2) Connect the DC Calibrator (Item A, Table 3-1) to the instrument.

3) Select the 200mV range, and apply positive 100 mVdc to the DMM. The reading must be within the limits specified in Table 3-2.

4) Select each remaining range and apply the required voltage as specified in Table 3-2, verify that the reading is within specifications.

5) Repeat all checks with negative voltage.

TABLE 3-2.
DC Voltage Performance Check

Range	Applied Voltage	Allowable Readings at 18° to 28°C
200 mV	100.00 mV	99.93 to 100.07
2 V	1.0000 V	0.9995 to 1.0005
20 V	10.000 V	9.995 to 10.005
200 V	100.00 V	99.95 to 100.05
1200 V	1000.0 V	999.5 to 1000.5

c. AC Volts Checkout.

1) Select ac voltage readings with the AC/DC and V pushbuttons.

2) Connect the AC Calibrator (Item B, Table 3-1) to the DMM. Set the calibrator frequency to 1 kHz.

3) Set the DMM to the 200 mV range and apply 100 mV ac to the DMM. The reading must be within the limits specified in Table 3-3.

4) Select the 2, 20 and 200 volt ranges and apply the required voltages as specified in Table 3-3. Verify that the readings are within specifications.

5) To check the 1000 volt range, connect the AC Calibrator Amplifier (Item C, Table 3-1) to the output of the AC Calibrator per the manufacturer's instructions. Set it for an output of 1000 volts ac rms and verify that the DMM readings is within the specified limits.

TABLE 3-3.
AC Voltage Performance Check

Range	Applied Voltage	Allowable Readings at 18° to 28°C
200 mV	100.00 mV	99.15 to 100.85 mV
2 V	1.0000 V	0.9925 to 1.0075 V
20 V	10.000 V	9.935 to 10.065 V
200 V	100.00 V	99.35 to 100.65 V
1000 V	1000.0 V	993.5 to 1006.5 V

d. Resistance Checkout.

1) Select resistance readings by pressing the Ω pushbutton.

2) Set the HI/LO pushbutton to HI and select the 20k Ω range.

3) Connect the decade resistor (Item D, Table 3-1) to the DMM.

4) Set the decade resistor to zero and measure the resistance of the test leads. Subtract this reading from the displayed reading in all of the following steps.

5) Set the decade resistor to 19.000 kΩ. Verify that the reading is within the limits specified in Table 3-4.

6) Select the next range and measure the next resistance as specified in Table 3-4. Verify that each reading is within specifications. Test each item in the table, switching the HI/LO pushbutton as indicated.

TABLE 3-4.
Resistance Performance Check

HI/LO	Range	Resistance	Allowable Reading at 18° to 28°C
HI	20 kΩ	19.000 kΩ	18.990 to 19.010 kΩ
HI	200 kΩ	190.00 kΩ	189.90 to 190.10 kΩ
HI	2000 kΩ	1.9000 MΩ	1899.0 to 1901.0 kΩ
HI	20 MΩ	19.000 MΩ	18.980 to 19.020 MΩ
LO	2 kΩ	1.9000 kΩ	1.8957 to 1.9043 kΩ
LO	20 kΩ	19.000 kΩ	18.957 to 19.043 kΩ
LO	200 kΩ	190.00 kΩ	189.57 to 190.43 kΩ
LO	2000 kΩ	1900.0 kΩ	1895.7 to 1904.3 kΩ

e. DC Current Checkout.

1) Select dc current readings with the AC/DC and A pushbuttons.

2) Connect the dc current source (Item E, Table 3-1) to the DMM.

3) Select the 200 µA range and apply a current of 100.00 µA to the DMM. The reading must be within the limits in Table 3-5.

4) Select each range and apply the required current as specified in Table 3-5. Verify that the reading is within specifications.

f. Analysis. If the instrument is out of specified limits at any point in Tables 3-2 through 3-5, calibrate the DMM as described in Section 4. If the unit is still under warranty, refer to the note in Paragraph 3-1.

TABLE 3-5.
DC Current Performance Check

Range	Applied Current	Allowable Reading at 18° to 28°C
200 µA	100.00 µA	99.78 to 100.22 µA
2 mA	1.0000 mA	0.9788 to 1.0022 mA
20 mA	10.000 mA	9.978 to 10.022 mA
200 mA	100.00 mA	99.78 to 100.22 mA
2000 mA	1000.0 mA	997.8 to 1002.2 mA
20 A	10.000 A	9.948 to 10.052 A

SECTION 4. CALIBRATION

4-1. GENERAL. Calibration should be performed yearly (every 12 months) or whenever performance verification (See Section 3) indicates that the Model 179 DMM is out of specifications. If any step in the calibration procedure cannot be performed properly, refer to Section 5 for Troubleshooting Information or contact your Keithley representative or the factory.

4-2. RECOMMENDED TEST EQUIPMENT. Recommended test equipment for calibration is listed in Table 4-1. Alternate test equipment may be used. However, the accuracy of the alternate test equipment must be at least 10 times better than the instrument specification, or equal to Table 4-1 specifications.

TABLE 4-1.
Recommended Test Equipment For Calibration.

Item	Description	Specification	Mfr.	Model
A	DC Calibrator	0.1V, 1V, 10V, 100V, 1000V ±0.002% or 20µV	Fluke	343A
B	AC Calibrator	0.1V, 1V, 10V, 100V ±0.022%	H-P	745A
C	Decade Resistor	1.9KΩ, 190KΩ, ±0.01%	ESI	RS725

4-3. ENVIRONMENTAL CONDITIONS. Calibration should be performed under laboratory conditions having an ambient temperature of 20° to 26°C (68° to 78°F), and a relative humidity of less than 80%.

4-4. CALIBRATION PROCEDURE. Perform the following adjustments to calibrate the 179 DMM and restore its operation to specified limits.

a. Calibration Shield Installation. If the Model 1788 Battery Pack is installed in the instrument it must be removed and the calibration shield reinstalled before calibration.

WARNING
Disconnect the line cord before removing the case cover.

1) Turn off the power and disconnect the line cord. Remove four screws from the bottom of the case and separate the top cover from the bottom cover.

2) Push back the ground clip (shown in Figure 2-2) from the upper side of the battery pack and remove the battery pack from the spacers.

3) Calibration may be performed on battery power as long as the battery pack is sufficiently charged. Leave the battery pack plugged into the instrument, but set the battery pack behind the DMM on the bench or table.

4) Set the calibration shield in place on the spacers. The shield should read correctly when viewed from the front of the instrument.

5) Slide the ground clip over the top of the calibration shield so that it contacts the upper surface of the shield.

6) If battery power is not to be used, plug in the line cord.

b. Calibration Instructions.

WARNING

Some procedures require the use of high voltage. Take care to prevent contact with live circuits which could cause electrical shock resulting in injury or death.

1) Refer to Table 4-2 and perform the listed adjustments in the sequence indicated. Note that the step sequence is also indicated on the calibration shield by boxed numerals. The sequence must be followed exactly because the adjustments are inter-related and dependent on the preceeding steps.

2) If the indicated adjustment cannot be made to obtain the specified reading, refer to Section 2-5 for Troubleshooting Information.

TABLE 4-2.

Calibration Procedure

Step	Function	Range	Input	Adjustment Point	Desired Reading	Test Equipment*
1	DC V	2 V	+1.9 V	R107	1.9000	DC Calibrator (A)
2	DC V	200 mV	+190 mV	R108	190.00	DC Calibrator
3	DC V	2 V	+1.9 V	R107	1.9000	DC Calibrator
4	Ω LO	200 kΩ	Short	R149	Set Front Panel Zero to Mechanical Center.	None
5	Ω LO	200 kΩ	Short	R112	00.0±10 digits	None
6	Ω LO	200 kΩ	Short	R149	00.00 ±2 digits	None
7	Ω HI	200 kΩ	190 kΩ	R127	190.00	Decade Resistor(C)
8	Ω LO	2 kΩ	1.9 kΩ	R129	1.9000	Decade Resistor
9	DC V	200 V	+190 V	R103	190.00	DC Calibrator
10	DC V	20 V	+19 V	R126	19.000	DC Calibrator
11	DC V	1000 V	+1000 V	R128	1000.0	DC Calibrator
12	AC V	20 V	1 V at 1 kHz	R142	1.000	AC Calibrator (B)
13	AC V	20 V	10 V at 1 kHz	R143	10.000	AC Calibrator
14	AC V	20 V	1 V at 1 kHz	R142	1.000	AC Calibrator
15	AC V	20 V	10 V at 1 kHz	R143	10.000	AC Calibrator
16	AC V	200 V	100 V at 10 kHz	C106	100.00	AC Calibrator
17	AC V	20 V	10 V at 10 kHz	C112	10.000	AC Calibrator
18	AC V	2 V	1 V at 10 kHz	C111	1.0000	AC Calibrator

* See Table 4-1.

SECTION 5. TROUBLESHOOTING.

5-1. GENERAL. The troubleshooting instructions contained in this section are intended for qualified personnel having a basic understanding of analog and digital electronic principles and components used in a precision electronic test instrument. Instructions have been written to assist in isolating the defective circuit or subcircuit. Isolation of the specific defective component has been left to the technician.

NOTE

For instruments that are still under warranty (less than 12 months since date of shipment), if the instrument's performance falls outside specifications at any point, contact your Keithley representative or the factory immediately.

5-2. TROUBLESHOOTING PROCEDURE. This section contains tables listing step-by-step checks of the major DMM circuits described in Section 6, Theory of Operation. Proceed as follows:

a. In general, start troubleshooting with Table 5-1, Line Power Checks, to verify that the power supplies are providing the specified voltage to the electronic components.

b. If trouble occurs on battery power only, or if battery operating time is substantially less than 6 hours after overnight charging, test the batteries and charging circuit per Table 5-2.

c. Proper operation of the A/D converter & display should be verified before troubleshooting the signal conditionings. Check these circuits per Tables 5-4 and 5-3, respectively.

d. Problems with ac voltage ranges may involve the ac attenuator, the ac amplifier, or the ac converter. Check these circuits per Table 5-6 and 5-8.

e. Check the dc voltage attenuator per Table 5-5 if problems occur with the dc voltage ranges. Check the resistance circuit per Table 5-7 if resistance measurements are erratic.

f. If problems occur with current readings, check the current shunts and related circuits per Table 5-9.

g. All measurements are referenced to analog common (ground clip).

TABLE 5-1.
Line Power Checks

Step	Item/Component	Required Condition	Remarks
1	S101 line switch	Must be set to 105-125V or 210-250V as appropriate.	
2	S102 LINE/BAT switch	Must be set to BAT for use with battery pack.	
3	F101 line fuse	Continuity.	
4	P1007 line cord	Plugged into live receptacle.	
5		Turn on power.	
6	+5V pad*	+5 volts ±10%.	Output of VR104.
7	VR104, IN C108-2200µF (+)	+7 volts Minimum.	Output of CR101, input to VR104.
8	+15V pad*	+15 volts ±10%.	Output of VR102.
9	TP1*	+17.5 volts minimum.	Output of CR102, input to VR102.
10	-15V pad*	-15 volts ±10%.	Output of VR101.
11	TP2*	-17.5 volts minimum.	Output of CR102, input to VR101, NOTE: Hot regulator may indicate shorted load.

* On main printed circuit board.

TABLE 5-2.
Battery Power Checks

Step	Item/Component	Required Condition	Remarks
1		Check AC line power per Table 5-1.	
2		Turn off power.	
3	S102 LINE/BAT switch	Move to BAT.	
4	P1007 line cord	Plugged into live receptacle.	Charge circuit checks.
5	F301	Remove fuse and connect ammeter to fuse clip. 0 to 500mA charging rate, varies with line voltage and battery state of charge.	No charge, see step 5A. Correct charging but short battery operating time, see step 6.
5A	BT301 Batteries	Full charge is ≈9.8 volts over 4 cells. R301 adjusts charging rate (float voltage).	If voltage is low and adjustment of R301 does not start charging, see steps 7 and following. If voltage is low and adjustment of R301 does start charging, see Table 5-10 for adjustment of battery charge voltage.
6	Each battery cell voltage <u>during</u> charging.	Less than 3 volts for any cell.	High voltage or zero indicates damaged cell.
7	Q301 anode	Full wave rectified voltage, 15 VDC nominal.	Output of CR101.
8	C304 +	+17.5 volts minimum.	Output of CR102. Triggers Q301 gate thru R306 and CR301 unless Q302 is on.
9	Q302	Should saturate only when battery approaches full charge.	
10	VR301	8.2V zener.	
11		Unplug line cord & turn power on.	Discharge checks.
12	P1004 pin 8 or U301 pin 11	100 kHz 5V square wave.	Clock input. If no input, see step 12A.
12A	VR104, IN	+7 volts minimum.	Battery voltage input to VR104.
13	Q307 and Q308 base	Square wave, ±0.7 volts at 25 kHz.	Output of U301, ÷ 4.
14	Q307, Q308 collector	Must oscillate from saturation to twice battery voltage (≈19 volts) at 25 kHz.	Inverter.
15	C304, C305	±17.5 volts minimum (±25 volts typical with fully charged bat.).	Inverter Output, input to VR101 & VR102

TABLE 5-3.
Display

Step	Item/Component	Required Condition	Remarks
1		Turn on power. Any function or range except OHMS.	
2	+5V* or J1001, pin 5	+5 volts ±10%.	If low, check per Table 5-1.
3	U202, pins 2, 6, 7, 9 and 13	Digit drive LOW = Enabled.	LED cathode.
4	U201, pins 1, 2, 6 and 7	HI = Enabled.	BCD input to segment decoder/driver.
5	U201, pin 4	Positive-going signal lasting for 200 clock pulses.	Leading digit suppression. Output of U107A.
6	J1002, pin 9	Polarity line (SIGN) HI = off LO = -.	NOTE: Polarity output (in at J1002, pin 9) is inverted for VDC on 20 volt and higher ranges. Polarity output is disabled on AC and Ω.
7	J1001, pins 1, 2, 3 and 4.	Appropriate DP line high (on).	

* On main printed circuit board.

TABLE 5-4.
A/D Converter

Step	Item/Component	Required Condition	Remarks
1		Turn on Power. Select 2 volt DC range and short inputs.	On this function and range (also on 200 mV DC), input HI connects thru R106, R136, and R135G to A/D, without attenuation.
2	Display	.0000 ±1 digit.	
3	TP10*	0.0000 volts.	A/D signal input.
4	TP8*	+1.00 volt.	Reference output.
5	TP3*	+100 millivolts.	Reference output.
6	TP4*	6.3 ±0.25 volts.	Reference zener voltage.
7	U106, pin 7	+1.00 volt.	Reference input to U106.
8	CLK*	0 to +5V square wave at 100 kHz.	Clock input.
9	TP6*	+1.0 ±0.1 volt.	Stored autozero voltage.
10	U103, pin 11	+1.0 ±0.1 volt.	Σ-node voltage to integrator in U103.
11	TP7*	-1.2 ±0.2 volt.	U103 integrator output voltage.
12	U104, pins 2, 3, and 6	+1 volt.	Buffer voltage on U104.
13	External voltage source	Apply +1.9000 volts. Display must read 1.9000 ±1 digit.	Calibration point.
14	TP7*	Waveform per Figure 5-1.	Integrator output.
15	U103, pin 2	Waveform per Figure 5-1 during ramping of integrator output.	Comparator output.
16		Select 200 mV range and short inputs.	
17	Display	00.00 ±3 digits.	Proceed if out-of-limits. Change selected value of R145 if tests 18-26 meet required conditions.
18	TP10*	0.0000 volts.	A/D signal input.

* On main printed circuit board.

TABLE 5-4.
A/D Converter, continued

Step	Item/Component	Required Condition	Remarks
19	U106, pin 7	+0.100 volt.	Reference input to U106.
20	U103, pin 11	+1.000 ±0.1 volt.	Σ-node voltage to integrator in U103.
21	TP7*	-1.2 ±0.2 volts.	U103 integrator output voltage.
22	U104, pins 2, 3	+100 millivolts.	Buffer voltage on U104.
23	U104, pin 6	+1 volt.	Buffer voltage.
24	External voltage source	Apply +190 millivolts. Display must read 190.00 ±1 digit.	Calibration point.

* On main printed circuit board.

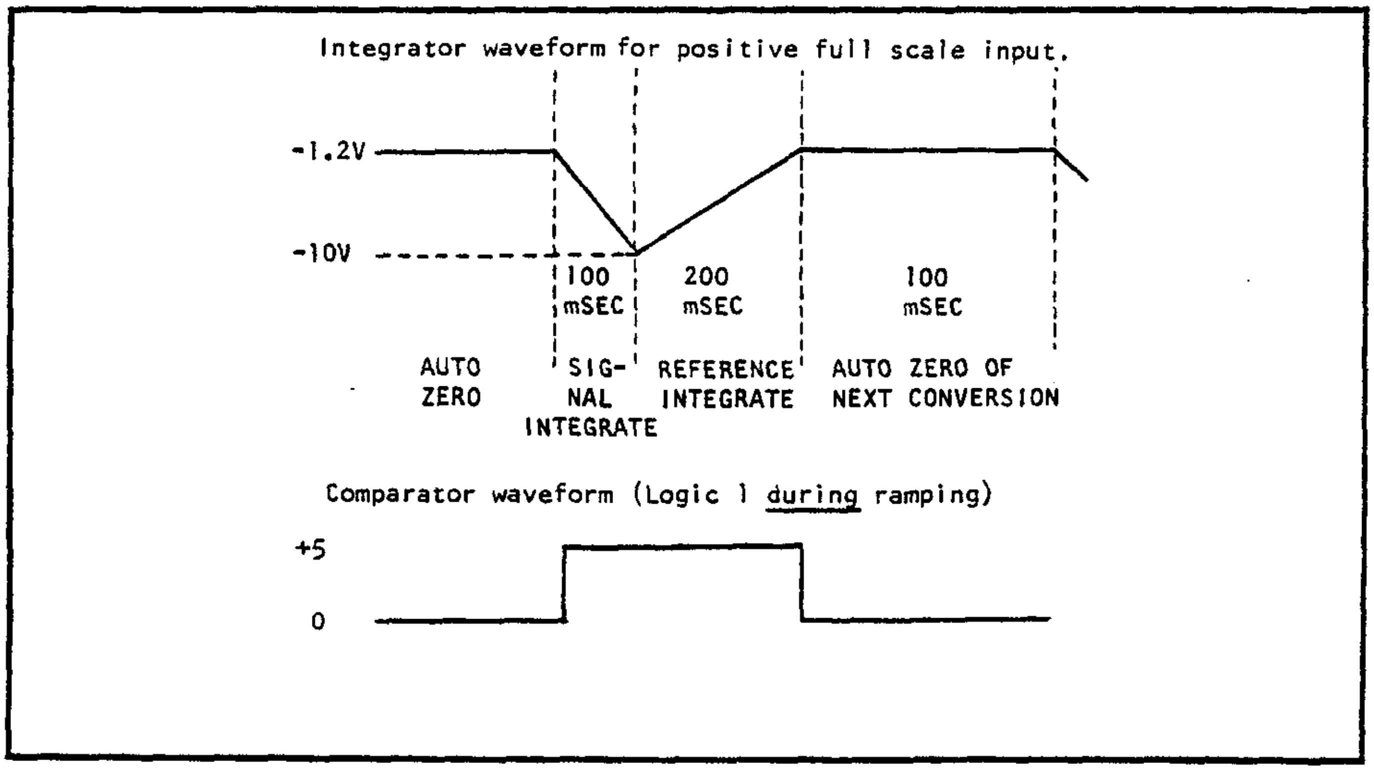


FIGURE 5-1. Integrator and Comparator Waveforms.

TABLE 5-5.
DC Volts Attenuator

Step	Item/Component	Required Condition	Remarks
1		Turn on power. Select 20 VDC range, and short inputs.	
2	R149	Front panel adjustment must zero the display.	
3	U101, pin 2	0.000 ±0.005 volts.	
4	External voltage source	Apply +10 volts from HI to LO.	Calibrated input.
5	TP5*	-1 volt	Output of U101.
6	External voltage source	(Apply +100 and +1000 volts on 200 and 1000 volt ranges.	Calibrated input.
7	TP5*	-1 volt	Output of U101 and feedback components, including relays.

* On main printed circuit board.

TABLE 5-6.
AC Volts Attenuator and X10 Amplifier

Step	Item/Component	Required Condition	Remarks
1		Turn on power. Select 2 VAC range.	NOTE: Full scale inputs should produce ≈2 volts output at TP9.
2	External voltage source	Apply 1 volt rms at 1 kHz.	Calibrated input.
3	TP9* & TP5	1 volt rms.	Output of U101 and feedback components.
4	External voltage source	10, 100 and 1000 volts rms on 20, 200 and 1000 volt ranges.	Calibrated input.
5	TP9* & TP5	1 volt rms on all ranges except 200 millivolts.	Output of U102 and feedback components, including relays.
6	External voltage source	Apply 1, 10, 100V @ 20kHz on 2, 20 and 200V ranges respectively.	C106, C111, C112, C113, and C114.
7	External voltage source	Apply 10V @ 45Hz on 20V range.	C105, C115, C116.
8		Select 200 mV range.	
9	External voltage source	100 millivolts at 1 kHz.	Calibrated input.
10	TP5*	100 millivolts rms.	Output of U101 and feedback components.
11	TP9*	1 volt rms.	Output of U102.

* On main printed circuit board.

TABLE 5-7.
Resistance Circuit.

Step	Item/Component	Required Condition	Remarks
1		Turn on power. Select Ω, HI and 200k range. Short inputs.	
2	U101, pin 2	Continuity to input HI.	K105.
3	TP10*	0.0 volt.	A/D input.
4	Ω switch, pin 11	+1 volt.	Reference voltage.
5	INPUT HI to LO	Remove short and measure open circuit voltage; must be +2 to +5 volts.	R150 & R151.
6	100k resistor	Apply to input.	Calibrated resistance.
7	TP10*	-1 volt.	A/D input.
8		Select LO range.	
9	Ω switch, pin 11	+100 millivolts.	Reference voltage.
10	TP10*	-100 millivolts.	A/D input.
11		Test other ranges in similar manner as needed.	NOTE: Reference loading by the current setting resistor does not affect readout since A/D converter is ratiometric.

* On main printed circuit board.

TABLE 5-8.
AC Converter

Step	Item/Component	Required Condition	Remarks
1		Turn on power. Select 20 VAC range.	
2	External voltage source	10 volts rms, 1 kHz.	Calibrated input.
3	TP9*	1 volt rms (approximate).	Input to converter.
4	U105, pin 6 or TP10*	+1 volt DC.	Output of U105.
5	R143	Gain adjustment must operate.	
6	Repeat steps 4 & 5	10 volts rms, 45 Hz.	Low frequency response.
7	Repeat steps 4 & 5	10 volts rms, 20 kHz.	High frequency response.

* On main printed circuit board.

TABLE 5-9.
Current Shunts

Step	Item/Component	Required Condition	Remarks
1	F102	Continuity.	
2	R123, R124, R137, R138, R139	Correct shunt value for specified range. See schematic.	Measure with ohmmeter.
3		Turn on power. Select DCA and 200 μA range.	
4	External voltage source	0 to 3 volts.	Clamping must occur at ±2 volts.

TABLE 5-10.
Adjustment of Battery Charge Voltage

Step	Item/Component	Required Condition	Remarks
1		Instrument off.	
2	R301	Turn full CCW (maximum charge rate).	
3	BT301	Monitor battery voltage for > 9.8V.	Fully charged cells require several minutes to reach this level. Discharged cells require several hours. ⚠ CAUTION: charging to >10V for longer than 30 min. will reduce battery life.
4	R301	When cells reach 9.8V, turn DMM on and adjust to maintain 9.8V across BT301.	

SECTION 6. THEORY OF OPERATION.

6-1. GENERAL. This section contains circuit descriptions for the Model 179 DMM and for the Model 1788 Battery Pack. An overall block diagram of signal flow is provided in Figure 6-1. The overall schematic diagram, drawing 28992E, is contained in the back of this manual.

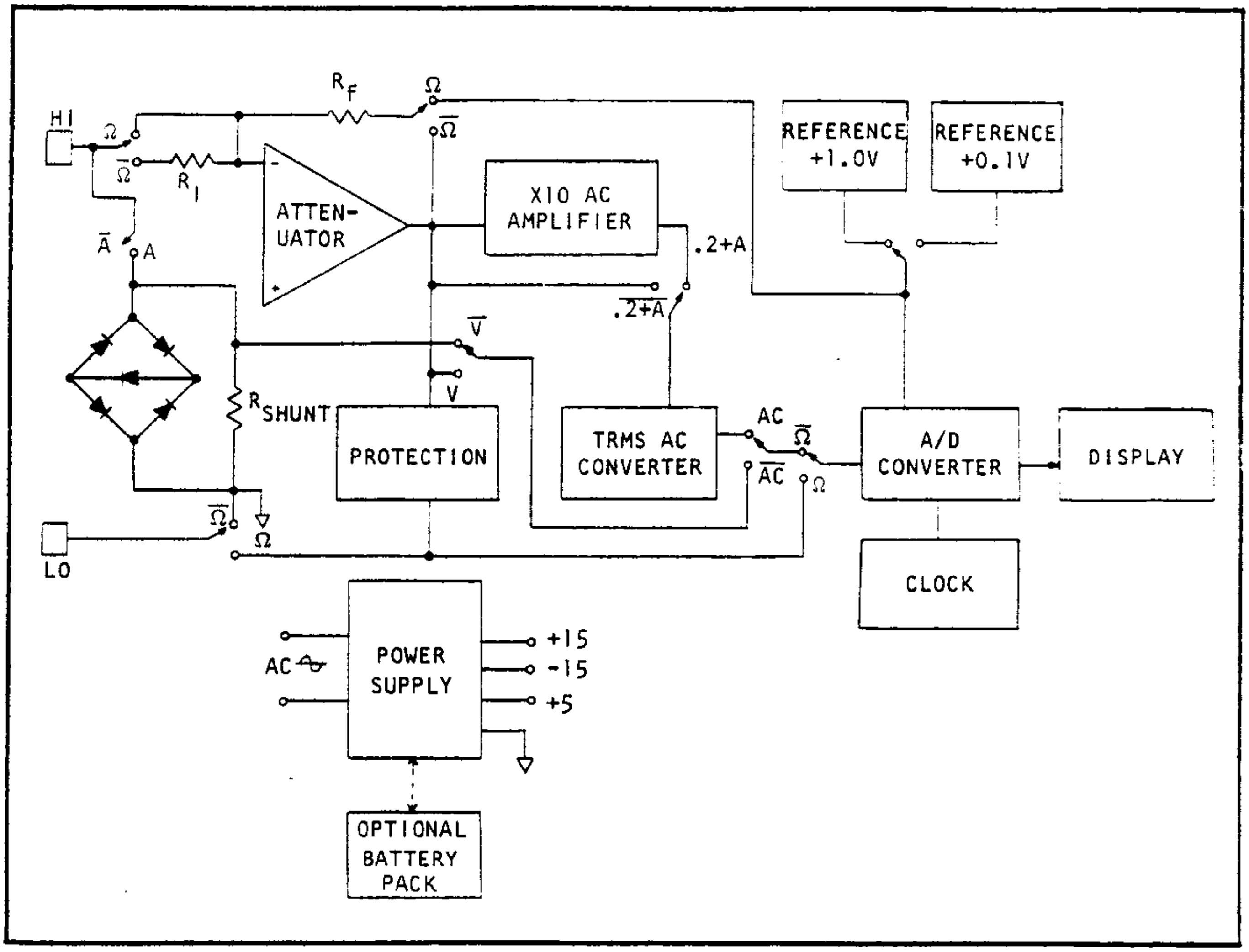


FIGURE 6-1. Simplified Signal Flow Block Diagram, Model 179 DMM

6-2. OVERALL OPERATION. The Model 179 DMM uses a 2-volt or 200-millivolt full scale analog-to-digital (A/D) converter with a 4-1/2 digit multiplexed display. Signal conditioning permits the A/D converter to handle full scale ac and dc voltage and current measurements over 5 decades, and to measure resistance over 5 ranges.

a. Signal Conditioning. Signal conditioning includes dc attenuation (except on the 2 volt and 200 millivolt ranges), ac attenuation and X10 amplification, ac-to-dc conversion, ohms conversion and current shunts as shown in Figure 6-2.

1) In the DCV mode, signal conditioning to the A/D converter is an active attenuator, except on the two lowest ranges. The A/D input is $-V_{HI-LO} \cdot \frac{Rf}{RI}$, except on the lowest ranges or under overload conditions. In the DCA mode, the voltage developed accross the shunt resistor is applied directly to the A/D converter at 200 millivolts full scale.

2) In the ACV mode, ac inputs pass through the attenuator on all ranges. The input is scaled to 2 volts rms full scale, including X10 amplification for the 200 millivolt range. The TRMS converter outputs a positive dc signal proportional to the true root mean square ac signal. This DC signal is the A/D input. In the ACA mode, shunt voltage is treated as a 200 millivolt signal.

b. Ohms Conversion. Resistance measurements are made by configuring the attenuator as a resistance-to-voltage converter. Attenuator stage voltage feedback resistors R_f function as amplifier input resistance connected to either the 0.1 volt reference (LO) or the 1.0 volt reference (HI). The unknown resistance is connected as a feedback resistor around the attenuation amplifier. The resulting voltage applied to the A/D converter is proportional to the unknown resistance.

c. A/D Converter. The A/D converter is a large scale integration (LSI) ratiometric device. Converter output is a multiplexed 5 digit binary coded decimal (BCD) number which is equal to the ratio of input voltage to reference voltage. A separate clock circuit supplies a 100 kHz timing input to the integrated circuit, which also multiplexes the BCD output. Full scale A/D inputs for various ranges and functions are listed in Table 6-1.

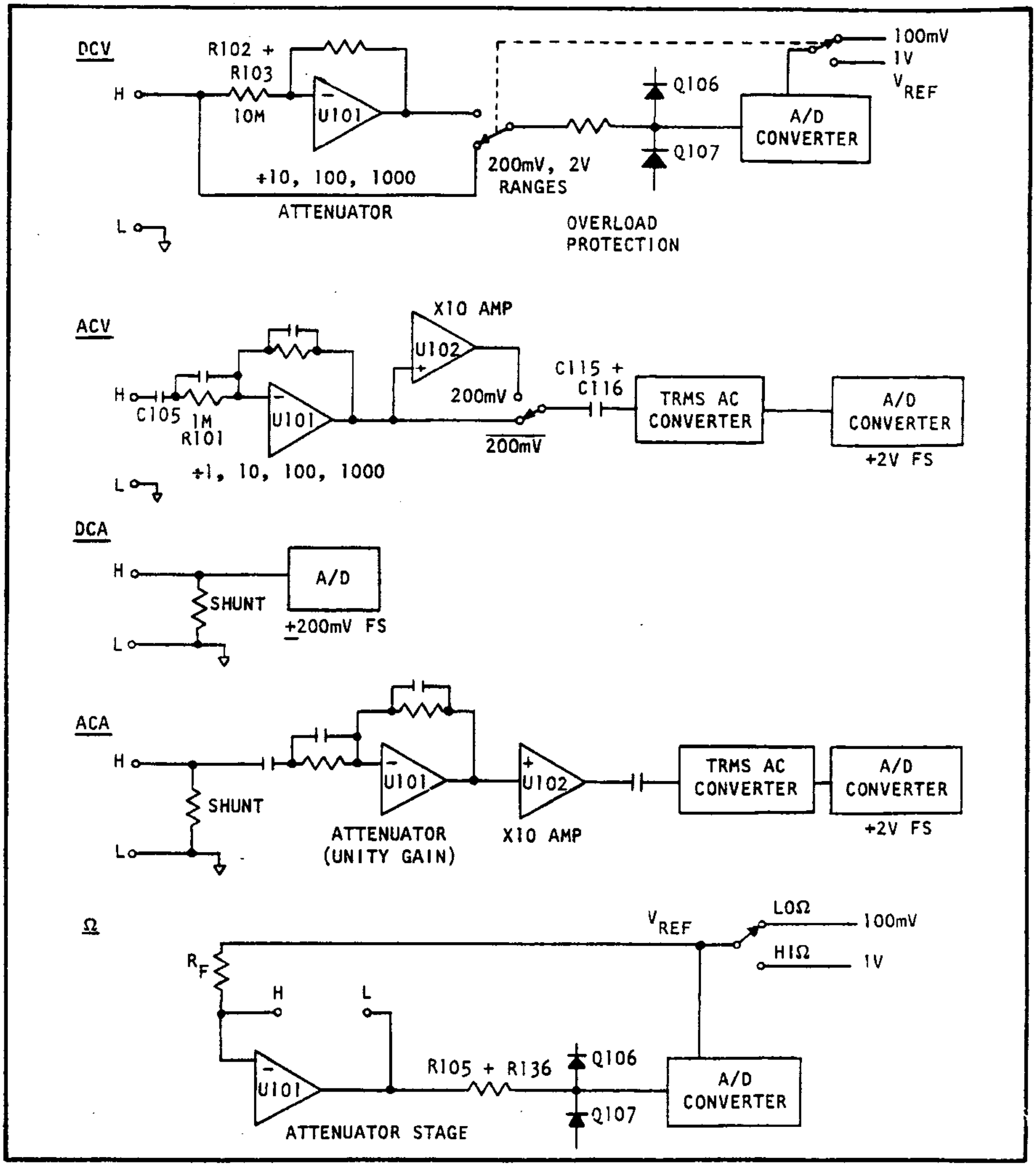


FIGURE 6-2. Attenuation and Ohms Conversion.

TABLE 6-1.
Full Scale A/D Inputs.

Function	Range	Full Scale A/D Input	Reference Voltage
DCV	200 mV	200 mV	0.1 V
DCV	2, 20, 200 1200 V	2 V	1.0 V
ACV	All	2 V	1.0 V
DCA	All	200 mV	0.1 V
ACA	All	2 V	1.0 V
Ω	HI	2 V	1.0 V
	LO	200 mV	0.1 V

6-3. ATTENUATION. When measuring ac and dc voltages, input signal conditioning is provided by inverting amplifier U101 and additional components as described below.

a. DC. Input resistance is set by R102 and R103. During calibration, R103 is adjusted to obtain a total input resistance of 10 MΩ. Both fine and coarse zero adjustments are provided since an amplifier output resolution of 10 microvolts is required for LO resistance measurements.

1) On the 2 volt and 200 millivolt ranges, input HI is connected to the A/D converter through protection resistors R106, R135G and R136. Diode-connected FET's Q106 and Q107 clamp the A/D input during overload.

2) On the 20, 200 and 1200 volt ranges, the amount of attenuation is selected by switching feedback resistors into the attenuator with relays K101, K102 and K103. Gain setting components and attenuation values are listed in Table 6-2.

TABLE 6-2.
DC Attenuation and Gain Setting Components.

Range	Gain Set Components	Relay/ Switch	Attenuation
200 mV			Signal bypasses attenuator
2 V			
20 V	R118, R126	K101	0.1
200 V	R119, R127	K102	0.01
1200 V	R120, R128	K103	0.001

b. AC Volts. Input resistance is 1MΩ (R101). Shunt capacitance is typically less than 75 pF. Additional conditioning is as follows.

1) For all ranges except the 200 millivolt range, the amount of attenuation is selected by switching feedback resistors into the attenuator with relays K101 through K104. For the 200 millivolt range, non-inverting X10 amplifier U102 boosts the signal to 2 volts full scale. Gain setting components and attenuation values are listed in Table 6-3.

TABLE 6-3.
AC Attenuation Gain Setting Components

Range	Gain Set Components	Relay Energized	Attenuation	Freq. Comp. Capacitors
200 mV	R118, R126	K101	1 (X10*)	C106, C111
2 V	R118, R126	K101	1	C106, C111
20 V	R119, R127	K102	0.1	C106, C112
200 V	R120, R128	K103	0.01	C106, C113
1000 V	R121, R122, R129	K104	0.001	C106, C114

* Signal applied to X10 ac amplifier U102.

2) On the 200 millivolt and 2 volt ranges, high frequency compensation is adjusted with capacitor C111, as shown in Table 6-3. On the 20 volt range, adjustment is performed with C112. On the 200 and 1000 volt ranges, adjustment is performed with C106. Some low frequency rolloff is introduced by input blocking capacitor C105, and ac converter input capacitors C115 and C116.

6-4. AC CONVERSION. The ac converter is a monolithic TRMS module. Output $V_{dc} = \sqrt{Avg(Vin)^2}$. Potentiometer R143 provides gain adjustment, and R142 establishes output zero. Settling time and ripple are determined by C110 and C120. Low frequency rolloff is a function of C120.

6-5. OHMS CONVERSION. During calibration, the 10 MΩ input resistance (R102 and R103) and all attenuator feedback resistors are adjusted for both ratio and absolute value. Therefore, these resistors can also serve as reference (current setting) for resistance measurements. In the Ω mode, the attenuation (feedback) resistors are disconnected from the output of the attenuation amplifier (U101) and are connected instead to the A/D converter reference voltage. Since two reference voltages and two A/D converter gains are available, the Model 179 DMM provides the option of measuring resistance with the sense current reduced by a factor of 10.

a. Range Selection. Operation of the range pushbuttons selects range resistors to provide the reference current listed in Table 6-4. Operation of the HI/LO pushbutton selects the 1 volt or 0.1 volt reference, respectively. Relay K105 is always energized in the Ω mode.

TABLE 6-4.
Resistance Range Setting Components

Range	Range Resistors	Relay/Switch	Nom. I_{REF} in HI Ω	Nom. I_{REF} in LO Ω
2 kΩ	R121, R122, R129	K104	-	100μA
20 kΩ	R120, R128	K103	100μA	10μA
200 kΩ	R119, R127	K102	10μA	1μA
2000 kΩ	R118, R126	K101	1μA	0.1μA
20 MΩ	R102, R103	1000 switch, pins 17, and Ω 8, 9.	0.1μA	-

b. Ω Circuit. For resistance measurements, relay K105 and terminals 4. 5, and 6 of the Ω pushbutton connect the input HI terminal directly to the amplifier summing node. Input LO is disconnected from ground and is connected to the A/D converter input through the protection components described below. The unknown resistance (R_X) then becomes the amplifier feedback resistance.

1) Current flow in the unknown resistance is from input HI to input LO. At full scale, the voltage across R_X is either 2 volts (HI) or 200 millivolts (LO). Reference source loading does not affect accuracy since the A/D converter is ratiometric.

2) The HI terminal is clamped to analog common by Q101 and Q102. The instrument protection network at the amplifier output consists of a pulldown resistance (R104 and CR103, CR104 and CR105). R104 sinks approximately 150 microamps. During in-range measurements, this current is supplied by the reference voltage through CR105 and voltage through the amplifier (U101) and CR104. Overloads with input HI positive are sustained by CR105; diodes CR103 and CR104 sustain negative overloads. Open circuit voltage is set to less than 5V by R150 and R151 through CR103 and CR105. A/D protection in Ω is the same as in V except R105 is substituted for R106.

6-6. A/D CONVERTER. The A/D converter operates on the dual slope principle. The timing is divided into three periods as described below. Operation with high and low reference voltages is described separately in subparagraph d.

a. Auto-Zero. The auto-zero period (A, Figure 6-3) is 100 milliseconds in length, which corresponds to 10,000 clock pulses. During this period, reference voltage V_{REF} (see subparagraph d) is stored on capacitor C124. Capacitor C117 stores $V_{REF} + V_{OS1} - V_{OS2}$.

b. Signal-Integrate. The signal-integrate period (B, Figure 6-3) is 100 milliseconds in length. The A/D input is buffered by U104 (see subparagraph d) and integrated by U103. Positive signals generate a negative-going ramp at the integrator output (pin 14), while negative signals produce a positive-going ramp. The level of the integrated signal at the end of the signal-integrate period is proportional to the average of the applied signal during this period. Since signal integration continues for 100 milliseconds, the A/D converter exhibits high normal mode rejection for ac signals in multiples of 10 hertz, particularly the 50 and 60 hertz line frequencies.

c. Reference-Integrate. The reference-integrate period (C or D, Figure 6-3) is 200 milliseconds or 20,000 counts in length. During this period, the integrator is returned to baseline level by applying a reference voltage of a polarity opposite to that of the signal. A positive-going ramp is obtained by grounding the buffer input, while a negative going ramp is produced by the integration of 2 x V_{REF} (that is, V_{REF} + the voltage stored on C124). The time, or number of clock pulses required for discharge is proportional to the signal input. Digital output is from latches within U106 which store the number of clock pulses required for the integrator to return to baseline level. The maximum count during this period is 20,000 which corresponds to a discharge period of 200 milliseconds or full scale input.

d. Reference Voltages. Reference voltage V_{REF} may be either 1 volt or 0.1 volt. Switching through the pushbuttons turns on either Q104 (for 1 volt) or Q103 (for 0.1 volt). The voltages are provided by a divider across a temperature compensated zener diode. An operational amplifier on U103 provides the zener with a self-regulating bias. Use of the 0.1 volt reference increases converter sensitivity to 200 millivolts full scale, permitting accurate LO ohms operation, 10 microvolt resolution on dc voltage measurements, and dc amperage measurements with a full scale burden of 200 millivolts. Increased sensitivity is accomplished by switching input buffer U104 into a gain-of-10 configuration by turning on Q105. Auto-zero charging on C124 is to a 100 millivolt reference instead of a 1 volt reference. Integrator and comparator voltage levels are unaffected by buffer gain. Buffer offset voltage is zeroed, and resistors R146 plus R144 or R145, which are selected at test, null any remaining zero offset on the 200 millivolt range.

6-7. DISPLAY. Five light-emitting diodes (LED) are driven by U201, which is a CMOS BCD-to-seven segment decoder/driver with bipolar current-sourcing outputs. Segment currents are limited to approximately 20 milliamperes peak by resistor network R202. The LED readout is a multiplexed, common-cathode configuration with Darlington array U202 sequentially sinking current from each digit. Blanking of the overrange digit is accomplished by gates U107A and U107B. Emitter-follower Q108 ensures that CMOS-compatible levels are maintained on U107A, pin 1, regardless of the loading of U202. The minus polarity readout is blanked on ac voltage and resistance ranges by contacts on the pushbutton switch. Proper decimal point position is determined by the combination of function and range selected.

6-8. CURRENT MEASUREMENTS. In the A mode, the signal is switched into one of five current shunts ahead of the attenuator section. For dc current measurements, the shunt voltage drop is applied directly to the A/D converter input at 200 millivolts full scale. For ac current measurements, the shunt voltage drop is treated as a 200 millivolt ac signal and passes through the ac attenuator and the X10 ac amplifier. Overload clamping occurs at three diode drops which is a level high enough to permit high crest factor current waveforms. On the Model 179-20A, a sixth current shunt is added and the principle of operation is the same as that described above.

6-9. AC POWER SUPPLY. When the DMM is operated from ac line power, the power supply furnishes +5, +15, and -15 volts from regulators VR104, VR102 and VR101, respectively. Full-wave rectified ac from bridge rectifiers CR101 and CR102 is filtered by reservoir capacitors C108, C104 and C103 and is applied to the linear voltage regulators.

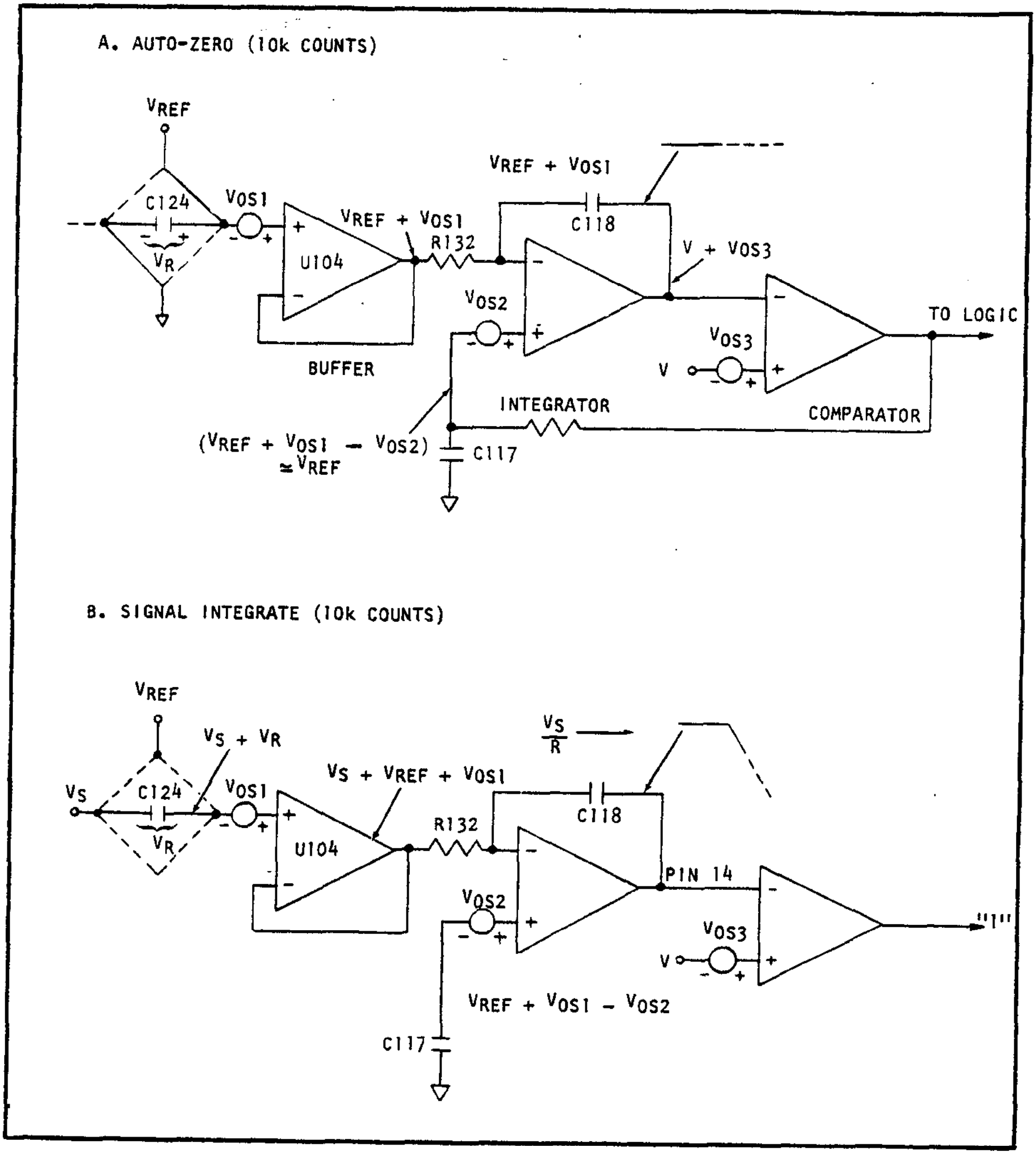
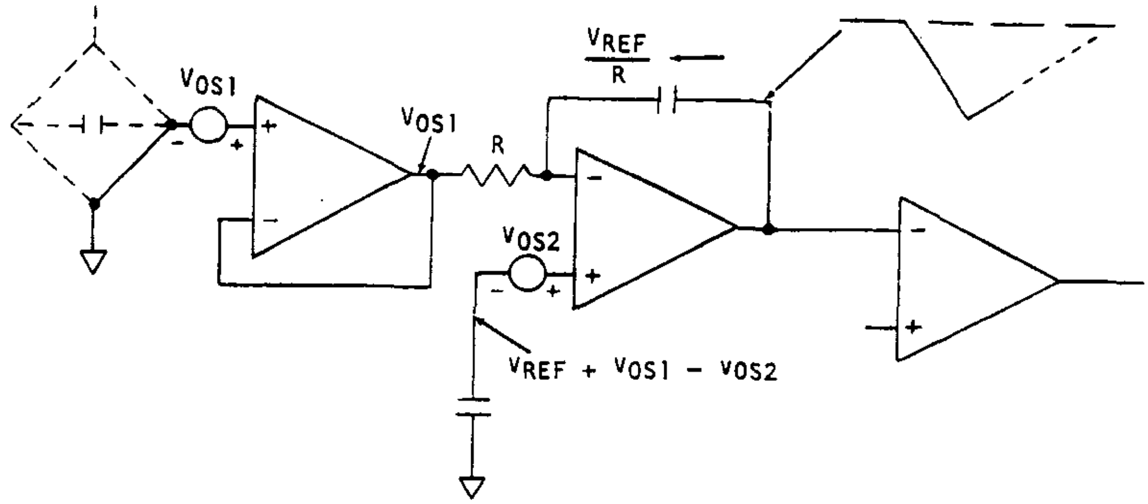


FIGURE 6-3. A/D Converter Function (Sheet 1 of 2)

C. NEGATIVE REFERENCE INTEGRATE (20k COUNTS AT FULL SCALE)
(POSITIVE INPUTS-TO A/D)



D. POSITIVE REFERENCE INTEGRATE (20k COUNTS AT FULL SCALE)
(NEGATIVE INPUTS TO A/D)

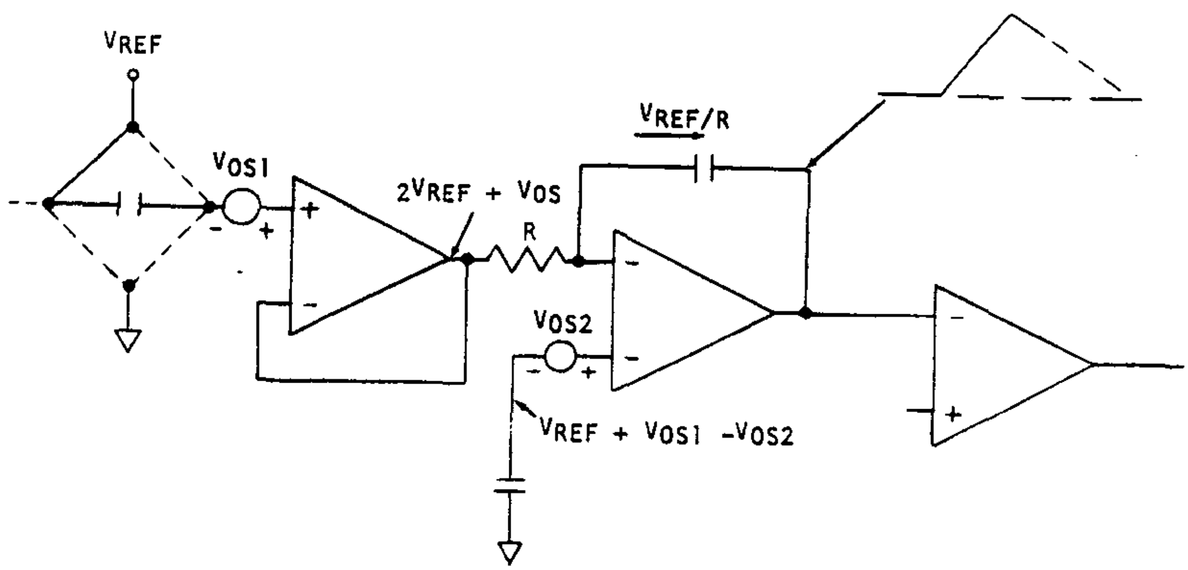


FIGURE 6-3. A/D Converter Function (Sheet 2 of 2)

6-10. MODEL 1788 BATTERY PACK. When the Model 1788 Battery Pack is installed in the DMM, S102 must be set to the BAT position to provide additional secondary voltage for battery charging. S102 also switches the input to VR104 from bridge rectifier CR101 to batteries BT301. Four 2-volt, 2.5 ampere-hour lead-acid cells supply approximately 9.8 volts at full charge. After six hours of use on battery power, the battery pack should be recharged to ensure long battery life.

a. Battery Charging Circuit. While the DMM is plugged into line power and the battery pack is installed, battery charging proceeds as follows:

1) Full-wave rectified voltage from CR101 is applied to the anode of Q301, which is an SCR which regulates charging voltage. When Q301 is triggered on by a sufficient gate-cathode voltage differential, the batteries receive charge. Charging continues as long as the bridge output voltage exceeds battery voltage by 1 volt or more. Resistor R304 limits charging current when recharging a set of completely discharged cells. A filtered positive output from CR102 (or T301) provides the necessary gate turn-on bias thr h R306 and diode CR301. Resistor R303 ensures proper high-temperature operat... of Q301.

2) When the battery voltage reaches the preset float voltage of 9.8 volts, zener VR301 conducts sufficient current to turn on Q302 and thus remove the gate trigger voltage from Q301. Float voltage is adjusted with R301. This is a factory adjustment which normally does not need field readjustment.

b. Battery Operation and Shutdown Circuit. The DMM operates as follows on battery power:

1) When the power is turned on, the batteries are connected to the input of VR104 to supply +5 volts for the logic, display and the clock circuit. The clock output is applied to the A/D converter as described in Paragraph 6-6 and also to U301, which is a divide-by-four binary counter. The outputs of U301 drive a dc-to-dc inverter which is synchronized to the A/D converter to filter out inverter noise. The 25 kilohertz operating frequency is optimal for the small transformer size, and results in low switching losses. Blocking capacitors C301 and C302 protect Q307 and Q308 from damage if the drive is lost. Two half-wave rectifiers (CR304 and CR305) on the secondary of T301 provide rectified ac to filter capacitors C304 and C305 which provide power to +15 and -15 volt regulators VR102 and VR101.

2) To prevent permanent loss of battery capacity caused by deep discharge, a shutdown circuit stops operation on battery power when the battery voltage drops below approximately 7.2 volts. Shutdown is performed by micropower voltage detector U302. The open-collector output (U302, pin 4) saturates low and turns off pass transistor Q309 when the input voltage (at U302, pin 3) drops below 1.15 volts (typical). Resistor R314 provides sufficient hysteresis to prevent discharge from resuming when the battery voltages rises following disconnection of the load.

SECTION 7. REPLACEABLE PARTS

7-1. GENERAL. This section contains information for ordering replacement parts. The parts list is arranged in alphabetical order of their Circuit Designations.

7-2. ORDERING INFORMATION. To place an order or to obtain information concerning replacement parts, contact you Keithley representative or the factory. See the inside front cover for addresses. When ordering, include the following information:

a. Instrument Model Number.

b. Instrument Serial Number.

c. Part Description.

d. Circuit Designation (if applicable).

e. Keithley Part Number.

7-3. MODEL 1789 MAINTENANCE KIT. The Model 1789 contains a complement of spare parts that will maintain up to ten Models 178, 179, or 179-20A DMMs (or any combination thereof) for approximately one year. Specify Model 1789 Maintenance Kit when ordering.

7-4. FACTORY SERVICE. If the instrument is to be returned to the factory for service, please complete the Service Form which follows this section, and return it with the instrument.

7-5. SCHEMATIC.

a. Model 179 4-1/2 digit TRMS Multimeter: Schematic No. 28992E (Page 7-10). This schematic also describes the Model 1788 Rechargeable Battery Pack.

7-6. COMPONENT LAYOUT.

a. Model 179 4-1/2 Digit TRMS Multimeter (Page 7-11).

b. Model 1788 Rechargeable Battery Pack (Page 7-13).

7-7. SPECIAL HANDLING OF STATIC SENSITIVE DEVICES. CMOS devices are designed to function at very high impedance levels for low power consumption. For this reason, a normal static charge build up on your person or clothing can be sufficient to destrov these devices. The following steps list the static sensitive devices in your Model 179 and provide instruction on how to avoid damaging them when they must be removed/replaced.

a. Static sensitive devices:

Keithley Part Number	Reference Designation
IC-102	U107
IC-103	U301
IC-168	U201

b. The above integrated circuits should be handled and transported only in protective containers. Typically they will be received in metal tubes or static protective foam. Keep the devices in their original containers until ready for use.

c. Remove the devices from their protective containers only at a properly grounded work bench or table, and only after grounding yourself by using a wrist strap.

d. Handle the devices only by the body. Do not touch the pins.

e. Any printed circuit board into which a device is to be inserted must also be grounded to the bench or table.

f. Use only anti-static type solder suckers.

g. Use only grounded tip soldering irons.

h. After soldering the device into the board, or properly inserting it into the mating receptacle, the device is adequately protected and normal handling can be resumed.

TABLE 7-1.
Cross-Reference of Manufacturers

MFR. CODE	NAME AND ADDRESS	FED. SUPPLY CODE	MFR. CODE	NAME AND ADDRESS	FED. SUPPLY CODE
A-B	Allen-Bradley Corp Milwaukee, WI 53204	01121	DLE	Dale Electronics Inc. Columbus, NE 68601	91637
A-D	Analog Devices Inc. Norwood, MA 02026	24355	DTN	Dielettron (Consolidated) New York City, NY 10013	
ACI	American Components, Inc. Conshohocken, PA 19428	14298	ECI	Electro Cube Inc. San Gabriel, CA 91776	14752
AMP	Amphenol Broadview, IL 60153	02660	EDI	Electronic Devices, Inc. Yonkers, NY 10710	83701
APX	Amperex Elkgrove Vlg, IL 60007	73445	EFJ	E. F. Johnson Co. Waseca, MN 56093	74970
BEC	Beckman Inst. Inc. Fullerton, CA 92634	73138	ERI	Erie Technological Prod. Erie, PA 16512	72982
BLD	Belden Mfg. Co. Chicago, IL 60644	70903	F-I	Fairchild Inst. Corp. Mountain View, CA 94043	07263
BRG	Berg Electronics Inc. New Cumberland, PA 17070	22526	FUS	Bussman Mfg. (Fusetron) St. Louis, MO 63107	71400
BRN	Bourns, Inc. Riverside, CA 92507	80294	G-E	General Electric Company Syracuse, NY 13201	03508
BUS	Bussman Mfg. Div. St. Louis, MO 63017	71400	G-I	General Instrument Corp. Newark, NJ 07104	72699
C-I	Components, Inc. Biddeford, ME 04005	06751	GLD	Gould, Inc. St. Paul, MN 55165	52431
C-W	Continential-Wirt Elec. Corp. Warminster, PA 18974	79727	H-P	Hewlett-Packard Palo Alto, Ca 94304	50434
CAD	Caddock Riverside, CA 92507	19647	INT	Intersil Inc. Cupertino, CA 95014	32293
CAN	ITT Cannon Electric Santa Ana, CA 92702	71468	IRC	IRC Division Burlington, IA 52601	07716
CLB	Centralab Division Milwaukee, WI 53201	71590	K-I	Keithley Instruments, Inc. Cleveland, Ohio 44139	80164
CLR	Clarostat Mfg. Co., Inc. Dover, NH 03820	12697	L-F	Littlefuse, Inc. Des Plaines, IL 60016	75915
CTS	CTS Corporation Elkhart, IN 46514	71450	MOL	Molex Downers Grove, IL 60515	27264
DIC	Dickson Electronics Corp. Scottscale, AZ 85252	12954	MOT	Motorola Semi Prod. Inc. Phoenix, AZ 85008	04713

TABLE 7-1. (Cont'd)

MFR. CODE	NAME AND ADDRESS	FED. SUPPLY CODE	MFR. CODE	NAME AND ADDRESS	FED. SUPPLY CODE
NAT	National Semi Corp. Santa Clara, CA 95051	27014	TEP	Tepro Electric Corp. Rochester, NY 14606	02985
NCI	National Components, Inc. West Palm Beach, FL		TPL	Temple Tecate, CA 92080	29505
NEL	Northern Engr. Labs Burlington, WI 53105	00815	TRW	TRW Capacitor Div. Ogallala, NB 69153	84411
P&B	Potter & Brumfield Princeton, IN 47670	12300	VIS	Vishay Resistor Products Malvern, PA 19355	18612
PAK	Paktron Vienna, VA 22180		VRN	Vernitron Laconia, NH 03246	13150
POM	Pomona Electric Pomona, CA 91766	05276	WAB	Wabash-Magnetics Wabash, IN 46992	01101
QTN	Q-Tron Santa Ana, CA 92705	25525			
RAY	Raytheon Company Quincy, MA	94144			
RCA	RCA Corporation Moorestown, NJ 08050	02734			
RCL	RCL Electronics, Inc. Manchester, NJ 03102	01686			
SIE	Siemens Corporation Iselin, NJ 08830	25088			
SIG	Signetics Corp. Sunnyvale, CA 94086	18324			
SIL	Siliconix Inc. Santa Clara, CA 95054	17856			
SPG	Sprague Electric Co. Visalia, CA 93278	14659			
SOL	Solitron Devices Inc. San Diego, CA 92123	22229			
STD	Standard Condensor Chicago, IL	97419			
T-I	Texas Instruments, Inc. Dallas, TX 75231	01295			
TEL	Tel Labs Manchester, NH 03102	94322			

REPLACEABLE PARTS LIST

BATTERIES (BT)
Model 1788 Battery Pack
"300" Series (Sch. 28992E-Pg. 7-15)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
BT301	Set of four "D" Cells, 8V	F6	---	*		
*	Lead-acid "D" cell, 2V, 2.5AH (Used for BT301, four required)			G-E	GE0225	BA-33

CAPACITORS (C)
"100" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 492-Pg. 7-13)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
C101	4.7µF, 20V, ETT	D-7	D-4	NCI	KNS475A020K	C-179-4.7
C102	4.7µF, 20V, ETT	D-7	E-4	NCI	KNS475A020K	C-179-4.7
C103	470uF, 35V, EAL	C-8	E-5	NIC	35ELA470	C-289-470
C104	470uF, 35V, EAL	C-8	E-5	NIC	35ELA470	C-289-470
C105	0.1µF, 1000V, MPF	C-3	F-5	STD	M2W-F-0.1µF	C-285-.1
C106	.25-1.5pF, 2000V, Teflon Trimmer	D-2	F-4	EFJ	273-101	C184
C107	1000pF, 500V, ±5%, Polystyrene	D-3	F-4	CLB	CPR-1000	C-138-1000
C108	2200uF, 15V, EAL	C-7	D-3	NAC	16FLA2200	C-290-2200
C109	3.3pF, ±0.5pF, 50VDC, CerD	E-2	E-3	NAC	DT200-3R3	C-291-3.3P
C110	1uF, 100V, ±10%, MPF	G-2	E-3	POT	4309C-105K	C-294-1
C111	.25-1.5pF, 2000V, Teflon Trimmer	D-2	E-3	EFJ	273-1-1	C-184
C112	1.9-15.8pF, 250V, Trimmer	D-2	E-3	EFJ	187-0109-005	C-284
C113	1100pF, 500VDC, ±1%, Silver Mica	D-2	F-3	G-I	RDM19FD112F03	C-278-110P
C114	1100pF, 500VDC, ±1%, Silver Mica	D-1	F-3	G-I	RDM19FD111F03	C-278-1100P use C-236-11
C115	33µF, 15V, ETT	F-2	E-3	NCI	KNS336D015K	C-228-33
C116	33µF, 15V, ETT	F-2	E-3	NCI	KNS336D015K	C-228-33
C117	1µF, 100V, ±10%, MPF	J-3	D-2	POT	4309C-105K	C-294-1
C118	.22uF, 200VDC, ±10%, MPF	J-2	D-2	POT	22-200-10-X363UW	C-269-.22
C119	NOT USED		---			
C120	1uF, 100V, ±10%, MPF	F-3	F-1	POT	4309C-105K	C-294-1
C121	4.7µF, 20V, ETT	D-8	D-2	NCI	KNS475A020K	C-179-4.7
C122	4.7µF, 20V, ETT	D-8	D-2	NCI	KNS475A020K	C-179-4.7
C123	.1µF, 200V, 20%, MPF	G-4	E-2	ECI	625B1C104	C-221-.1
C124	4µF, 100V, 20%, MPF	H-2	E-1	POT	0109-5432	C-294-4
C125	100pF, 1000V, CerD	F-5	F-2	CLB	DD-101	C-64-100P

"200" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 485-Pg. 7-14)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
C201	4.7uF, 20V, ETT	K-7	B-2	NCI	KNS475A020K	C-179-4.7

"300" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 451-Pg. 7-15)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
C301	4.7µF, 35V, EAL	F-7	E-3	NCI	KNS475A020K	C-179-4.7
C302	4.7µF, 35V, EAL	F-7	E-3	NCI	KNS475A020K	C-179-4.7
C303	1.0µF, 250V, MPY	F-7	E-3	AMP	C280AE/A1M	C-256-1
C304	100µF, 35VC	F-8	F-4	NIC	35-ULA-100	C-295-100
C305	100µF, 35VC	F-8	F-3	NIC	35-ULA-100	C-295-100

DIODES (CR)
"100" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 492-Pg. 7-13)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
CR101	Bridge Rectifier, 100V, 2A	C-6	D-5	EDI	PD10	RF-36
CR102	Bridge Rectifier, 1A, 400V	C-7	D-5	EDI	PF40	RF-46
CR103	Silicon Rectifier, 1A, 1000V	E-3	F-5	T-I	1N4007	RF-50
CR104	Silicon Rectifier, 1A, 1000V	E-3	F-5	T-I	1N4007	RF-50
CR105	Silicon Rectifier, 1A, 1000V	E-3	G-5	T-I	1N4007	RF-50
CR106	Rectifier, 75mA, 75V	D-8	D-4	T-I	1N914	RF-28
CR107	Rectifier, 75mA, 75V	J-2	D-2	T-I	1N914	RF-28
CR108	Rectifier, 75mA, 75V	J-2	D-2	T-I	1N914	RF-28

DIODES (CR) (CON'T)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
CR109	Rectifier, 75mA, 75V.	K-3	F-2	T-I	1N914	RF-28
CR110	Rectifier, 75mA, 75V.	J-3	F-2	T-I	1N914	RF-28
CR111	Bridge Rectifier, 5A, 50V	A-3	G-3	EDI	PE05	RF-48
CR112	Rectifier, 3A, 50V.	A-4	G-2	SOL	3A50	RF-34
CR113	Rectifier, 75mA, 75V.	H-1	C-2	T-I	1N914	RF-28

"300" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 451-Pg. 7-15)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
CR301	Rectifier, 75mA, 75V.	E-6	D-4	T-I	1N914	RF-28
CR302	Rectifier, 75mA, 75V.	F-7	E-3	T-I	1N914	RF-28
CR303	Rectifier, 75mA, 75V.	F-7	E-3	T-I	1N914	RF-28
CR304	Rectifier, 75mA, 75V.	E-8	F-4	T-I	1N914	RF-28
CR305	Rectifier, 75mA, 75V.	E-8	F-4	T-I	1N914	RF-28

DISPLAYS (DS)
"200" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 485-Pg. 7-14)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
DS201	±1 LED Digit	H-7	C-2	F-I	FND561	DD-17
DS202	7-Segment LED Digit	H-7	C-2	F-I	FND560	DD-16
DS203	7-Segment LED Digit	H-7	D-2	F-I	FND560	DD-16
DS204	7-Segment LED Digit	J-7	D-2	F-I	FND560	DD-16
DS205	7-Segment LED Digit	J-7	D-2	F-I	FND560	DD-16

FUSES (F)
"100" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 492-Pg. 7-13)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
F101	Fuse, Slo-Blo, 1/8A, 250V, 3AG. . .	B-7	D-4	BUS	MDL	FU-20
F102	Fuse, 2A, 250V, 3AG	A-3	F-3	LIT	312002	FU-13
F103*	Fuse, 20A, 250V, 3AB.	A-5	G-2	LIT	314020	FU-47

* On Model 179-20A Only

"300" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 451-Pg. 7-15)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
F301	2A, 250V, 3AG, Quick	F-6	C-3	L-F	312002	FU-13

CONNECTORS (J)
"100" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 492-Pg. 7-13)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
J1001	11-Pin Right Angle.	H-7	H-5	MOL	22-15-2111	CS-348-2
J1002	6-Pin Right Angle	H-6	H-2	MOL	22-15-2061	CS-348-1
J1003	3-Pin	B-8	---	MOL	2139-3	CS-287-3
J1004	8-Pin	D-8	D-5	MOL	2139-8	CS-287-8
J1005	Banana Jack, Black.	A-4	---	POM	1581	BJ-11-0
J1006	Banana Jack, Red.	A-3	---	POM	1581	BJ-11-2
J1007	NOT USED					

RELAYS (K)
"100" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 492-Pg. 7-13)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
K101	5V, Reed Type	B-8	E-4	COT	UF-40097	RL-56
K102	5V, Reed Type	B-8	F-4	COT	UF-40097	RL-56
K103	5V, Reed Type	A-8	F-4	COT	UF-40102	RL-59
K104	5V, Reed Type	A-8	F-4	COT	UF-40102	RL-59
K105	5V, Reed Type	A-8	F-4	COT	UF-40102	RL-59

CONNECTORS (P)
"1000" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 492-Pg. 7-13)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
P1001	6-Pin	H-7	G-5	MOL	22-03-2061	CS-247-1
P1002	11-Pin.	H-6	G-2	MOL	22-03-2061	CS-347-2
P1003	MALE.	B-8	D-5	MOL	A-2391-3A	CS-288-3
P1004	MALE.	D-5	D-3	MOL	A-2391-8A	CS-288-8
P1005	NOT USED					
P1006	NOT USED					
P1007	Line Cord	B-8	---	K-1	---	CO-9

TRANSISTORS (Q)
"100" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 492-Pg. 7-13)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
Q101	N-Chan, JFET.	D-3	E-4	INT	ITE4392	TG-77
Q102	N-Chan, JFET.	D-3	E-4	INT	ITE4392	TG-77
Q103	N-Chan, JFET.	H-2	D-2	INT	ITE4392	TG-77
Q104	N-Chan, JFET.	H-2	C-2	INT	ITE4392	TG-77
Q105	N-Chan, JFET.	J-3	D-2	INT	ITE4392	TG-77
Q106	N-Chan, JFET.	G-3	E-2	K-1	---	TG-128
Q107	N-Chan, JFET.	G-4	F-2	K-1	---	TG-128
Q108	NPN, Switch	H-6	G-2	MOT	2N3904	TG-47

"300" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 451-Pg. 7-15)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
Q301	Thyristor, SCR	D-6	C-4	MOT	106F1	TG-132
Q302	NPN, Switch	E-7	C-3	MOT	2N3904	TG-47
Q303	NPN, Switch	E-7	D-4	MOT	2N3904	TG-47
Q304	NPN, Switch	E-7	E-4	MOT	2N3904	TG-47
Q305	NPN, Switch	E-8	E-4	MOT	2N3904	TG-47
Q306	PNP, Silicon, TO-92 Case	E-7	E-4	K-1	---	TG-53
Q307	NPN, Switch	F-7	E-3	MOT	2N3725	TG-131
Q308	NPN, Switch	F-7	E-3	MOT	2N3725	TG-131
Q309	PNP, Silicon.	E-6	D-3	MOT	MPS-WA5	TG-133
Q310	PNP, Silicon, TO-92 Case	E-6	D-3	K-1	---	TG-53

RESISTORS (R)
"100" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 492-Pg. 7-13)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
R101	1MΩ, ±0.5%, 2W, MtF	D-3	E-4, E-5	ACI	PME80T9	R-267-1M
R102	9.88M, ±0.5%; .5W, 1200V, MtF	D-2	F-5	TRW	AR90T10	R-265-9.88M
R103	200KΩ, 10%, Cermet Trimmer.	C-2	F-5	BEC	89P	RP-89-200K
R104	100KΩ, 10%, 2W, Comp.	E-4	F-5	A-B	HB	R-2-100K
R105	47KΩ, 10%, 2W, Comp	G-4	F-5	A-B	HB	R-3-47K
R106	47KΩ, 10%, 2W, Comp	D-4	G-5	A-B	HB	R-3-47K
R107	100Ω, 10%, Cermet Trimmer	J-1	D-3	BRN	30-69-P	RP-64-100
R108	200Ω, 10%, Cermet Trimmer	J-1	D-3	BRN	30-69-P	R-64-200
R109	MATCHED SET WITH VR105.	J-1	D-3	TRW	MAR-5	R-263-99.8K (28798A)
R110	MATCHED SET WITH VR105.	J-1	D-3	TRW	MAR-5	R-263-4.59K (28798A)
R111	931Ω, 1%, 1/8W, MtF	J-1	D-3	IRC	CEA-TO-931	R-88-931
R112	50KΩ, 10%, Cermet Trimmer	E-3	E-3	BEC	72PMR	RP-97-50K
R113	200KΩ, 1%, 1/8W, MtF.	D-3	E-3	IRC	CEA-TO-200K	R-88-200K
R114	1.8M, 10%, 1/4W, Comp	D-3	E-3	MEP	CR25, 5%	R-76-1.8M
R115	100Ω, 1%, 1/8W, MtF	D-3	E-3	IRC	CEA-TO-100	R-88-100
R116	4.99KΩ, .1%, 1/10W, MtF	E-2	E-3	TRW	MAR-5, T13	R-263-4.99K
R117	44.9KΩ, .1%, 1/10W, MtF	E-2	E-3	TRW	MAR-5, T13	R-263-44.9K
R118	998KΩ, .1%, 1/4W, MtF	D-2	E-3	TRW	MAR-7, T13	R-264-998K
R119	99.8KΩ, .1%, 1/4W, MtF.	D-2	E-3	TRW	MAR-5, T13	R-263-99.8K
R120	9.98KΩ, .1%, 1/10W, MtF	D-2	F-3	TRW	MAR-5, T13	R-263-9.98K
R121	1.002KΩ, .1%, 1/10W, MtF.	D-1	F-3	TRW	MAR-5, T13	R-263-1.002K
R122	270KΩ, 10%, 1/4W, Comp.	D-1	F-3	MEP	CR25, 5%	R-76-270K
R123	.898Ω, .1%, 5W, WW.	B-4	F-3	TEP	TS5-.898	R-232-.898

RESISTORS (R) (CON'T)
"100" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 492-Pg. 7-13)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
R124	.1Ω, .1%, 7.5W, WW, 5-Terminal	B-4	F-2	TEL	SPECIAL	R-262-.1000
R125	120Ω, 10%, 1/4W, Comp	G-7	G-3	MEP	CR25, 5%	R-76-120
R126	5KΩ, 10%, Cermet Trimmer	D-2	E-3	BEC	72PMR	RP-97-5K
R127	500Ω, 10%, Cermet Trimmer	D-2	E-3	BEC	72PMR	RP-97-500
R128	50Ω, 10%, Cermet Trimmer	D-2	F-3	BEC	72PMR	RP-97-50
R129	50KΩ, 10%, Cermet Trimmer	E-1	F-3	BEC	72PMR	RP-97-50K
R130	143KΩ, .1%, 1/10W, MtF	J-2	D-2	TRW	MAR-5, T13	R-263-143
R131	856KΩ, .1%, 1/10W, MtF	J-2	D-2	TRW	MAR-5, T13	R-263-856
R132	100KΩ, 1%, 1/10W, MtF	J-2	D-2	IRC	CEA-TO-100K	R-88-100K
R133	26.7Ω, 1%, 1/8W, MtF	J-2	D-2	IRC	CEA-TO-26.7K	R-88-26.7K
R134	3.01Ω, 1%, 1/8W, MtF	J-3	E-2	IRC	CEA-TO-3.01K	R-88-3.01K
R135(A-J)	Thick Film Network	SEVERAL	E-2	K-1	---	TF-65
R136	47KΩ, 10%, WW, Comp	F-4	F-2	A-B	HB	R-3-47K
R137	9Ω, 0.5W, 0.1%, WW	B-4	F-3	TEL	SA3	R-252-9
R138	900Ω, 0.1%, 1/2W, MtF	C-4	F-3	DLE	MFF-1/2-TO-900	R-169-900
R139	90Ω, 1/2W, .1%, MtF	B-4	F-3	DLE	MFF-1/2-TO-90	R-169-90
R140	11KΩ, 1%, 1/8W, MtF	J-1	D-2	IRC	CEA-TO-11K	R-88-11K
R141	19.6KΩ, 1%, 1/8W, MtF	J-2	D-2	IRC	CEA-TO-19.6K	R-88-19.6K
R142	50K, 10%, Cermet Trimmer	G-3	E-2	BEC	72PMR	RP-97-50K
R143	500Ω, 10%, Cermet Trimmer	G-2	E-2	BEC	72PMR	RP-97-500
R144	Optional, Factory Selected	H-4	E-2	MEP	CR25, 5%	R-76-* (SEL)
R145	Optional, Factory Selected	H-5	E-2	MEP	CR25, 5%	R-76-* (SEL)
R146	1Ω, 5%, 1/4W, Comp.	H-5	E-2	MEP	CR25, 5%	R-76-1
R147	47KΩ, 10%, 1/4W, Comp	F-5	G-2	MEP	CR25, 5%	R-76-47K
R148	22M, 10%, 1/4W, Comp.	F-5	G-2	MEP	CR25, 5%	R-76-22M
R149	200K, 10%, Cermet Trimmer	D-3	G-1	BEC	89P	RP-89-200K
R150	3.3KΩ, 5%, 1/4W, Comp	E-3	F-5	MEP	CR25, 5%	R-76-3.3K
R151	12KΩ, 5%, 1/4W, Comp.	F-3	F-5	MEP	CR25, 5%	R-76-12K
R152	(Part of 28798A)	J-1	D-3	K-1	---	R-88-*
R153	(Part of 28798A)	J-1	D-3	K-1	---	R-88-*
R154	.01Ω, .25%, 7.5W, WW, 4-Terminal	K-1	G-2	TEL	SPECIAL	R-274-.01

"200" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 492-Pg. 7-13)

R201	120Ω, 1/4W, Comp.	H-7	C-2	MEP	CR25, 5%	R-76-120
R202	47Ω, Thick Film Network	J-7	E-2	BEC	899-3-R47	TF-64

"300" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 451-Pg. 7-15)

R301	20KΩ, 0.5W, POT	E-7	C-3	BEC	72PMR-20K	RP-97-20K
R302	330Ω, 10%, 1/4W, Comp	E-7	C-3	MEP	CR25, 5%	R-76-330
R303	1KΩ, 10%, 1/4W, Comp.	E-6	D-4	MEP	CR25, 5%	R-76-1K
R304	3.9KΩ, 20%, 3W, WW	D-6	D-4	TEP	TS3	R-268-3.9
R305	4.7KΩ, 10%, 1/4W, Comp.	E-7	D-3	MEP	CR25, 5%	R-76-4.7K
R306	33KΩ, 10%, 1/4W, Comp	D-8	C-3	A-B	CB-332-10%	R-76-3.3K
R307	82KΩ, 10%, 1/4W, Comp	F-7	E-3	MEP	CR25, 5%	R-76-82
R308	82KΩ, 10%, 1/4W, Comp	F-7	E-3	MEP	CR25, 5%	R-76-82
R309	10Ω, 10%, 1/4W, Comp.	D-8	F-4	A-B	CB-100-10%	R-76-10
R310	10Ω, 10%, 1/4W, Comp.	D-8	F-4	A-B	CB-100-10%	R-76-10
R311	100KΩ, %%, 1/4W, Comp	E-6	E-3	MEP	CR25, 5%	R-76-100K
R312	100KΩ, 5%, 1/4W, Comp	E-6	E-3	MEP	CR25, 5%	R-76-100K
R313	6.8MΩ, 5%, 1/4W, Comp	F-6	E-3	MEP	CR25, 5%	R-76-6.8M
R314	6.8MΩ, 5%, 1/4W, Comp	F-6	E-3	MEP	CR25, 5%	R-76-6.8M
R315	576KΩ, 1%, 1/8W, Comp	F-6	E-3	IRC	CEA-TO-576K	R-88-576K
R316	100KΩ, 1%, 1/8W, Comp	F-6	E-3	IRC	CEA-TO-100K	R-88-100K

SWITCHES (S)
"100" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 492-Pg. 7-13)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
S101	Line Voltage Selector	B-7	D-4	C-W	GG350PCDPDT	SW-318
S102	Line/Battery	C-6	D-4	K-1	---	SW-397
S103	11 Station Pushbutton	A-5	G-4	K-1	---	SW-402 (27696A)

TRANSFORMERS (T)
"100" Series (Sch. 28992E-Pg. 7-11)
- (PC-Board 492-Pg. 7-13)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
T101	Transformer, Power.	C-6	D-5	K-1	---	TR-168
T101	Transformer, Power (100/200 V). . .	C-6	D-5	K-1	---	TR-169
	"300" Series (Sch. 28992E-Pg. 7-11) (PC-Board 451-Pg. 7-15)					
T301	Transformer, Power.	F-7	F-3	K-1	---	TR-170

TEST POINTS (TP)
(Sch. 28992E-Pg. 7-11)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
TP1	Test Point.	C-8	---	K-1	---	---
TP2	Test Point.	C-8	---	K-1	---	---
TP3	Test Point.	H-2	---	K-1	---	---
TP4	Test Point.	J-1	---	K-1	---	---
TP5	Test Point.	E-3	---	K-1	---	---
TP6	Test Point.	J-3	---	K-1	---	---
TP7	Test Point.	J-2	---	K-1	---	---
TP8	Test Point.	H-2	---	K-1	---	---
TP9	Test Point.	F-2	---	K-1	---	---
TP10	Test Point.	G-3	---	K-1	---	---

INTEGRATED CIRCUITS (U)
"100" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 492-Pg. 7-13)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
U101	Operational AMP 8-Pin, TO-5	D-3	E-4	NAT	LH0022CH	IC-165
U102	Operational AMP 8-Pin, DIP.	E-2	E-3	NAT	LM301AN	IC-167
U103	4-1/2 Digit Analog-Processor. . . .	K-2	D-2	INT	8052A	LSI-12
U104	Operational AMP 8-Pin, TO-5	H-2	E-2	NAT	LH0042CH	IC-175
U105	TRMS Converter.	F-2	D-2	A-D	AD536J	IC-172
U106	4-1/2 Digit Logic Processor	J-4	E-2	INT	7103A	~~LSI-11~~ USE 179A-800
U107(A-D)	4011 CMOS Unbuffered.	SEVERAL	G-2	MOT	MC14011CP	IC-102
	"200" Series (Sch. 28992E-Pg. 7-11) (PC-Board 485-Pg. 7-14)					
U201	Segment Drive	K-7	E-2	MOT	4511	IC-168
U202	Digit Driver.	H-6	B-2	T-1	75492	IC-169
	"300" Series (Sch. 28992E-Pg. 7-11) (PC-Board 485-Pg. 7-14)					
U301	Dual D-Type Flip-Flop, 14-Pin DIP .	E-7	D-3	RCA	CD4013AE	IC-103
U302	1.1V Micro-Power Detector	F-6	E-3	INT	ICL8211CPA	IC-177

VOLTAGE REGULATORS (VR)
"100" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 492-Pg. 7-13)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
VR101	-15V, 3-Term	C-8	E-5	MOT	MC7915CT	IC-174
VR102	+15V, 3-Term, LO-Power.	C-8	E-5	MOT	MC78L15CP	IC-170
VR103	NOT USED					
VR104	+5V, 3-Term, TO-220	D-7	D-4	MOT	MC7805CT	IC-93
VR105	Reference Zener	J-2	D-2	K-1	---	(28798A)
	"300" Series (Sch. 28992E-Pg. 7-11) (PC-Board 451-Pg. 7-15)					
VR301	8.2 Volt, Zener	E-6	C-3	MOT	1N765A	DZ-61

CRYSTAL (Y)
"100" Series (Sch. 28992E-Pg. 7-11)
(PC-Board 492-Pg. 7-13)

Circuit Desig.	Description	Sch. Location	PC-Board Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
Y101	Quartz, ±0.01%, 100kHz.	F-5	F-1	NEL	NE34PE	CR-8

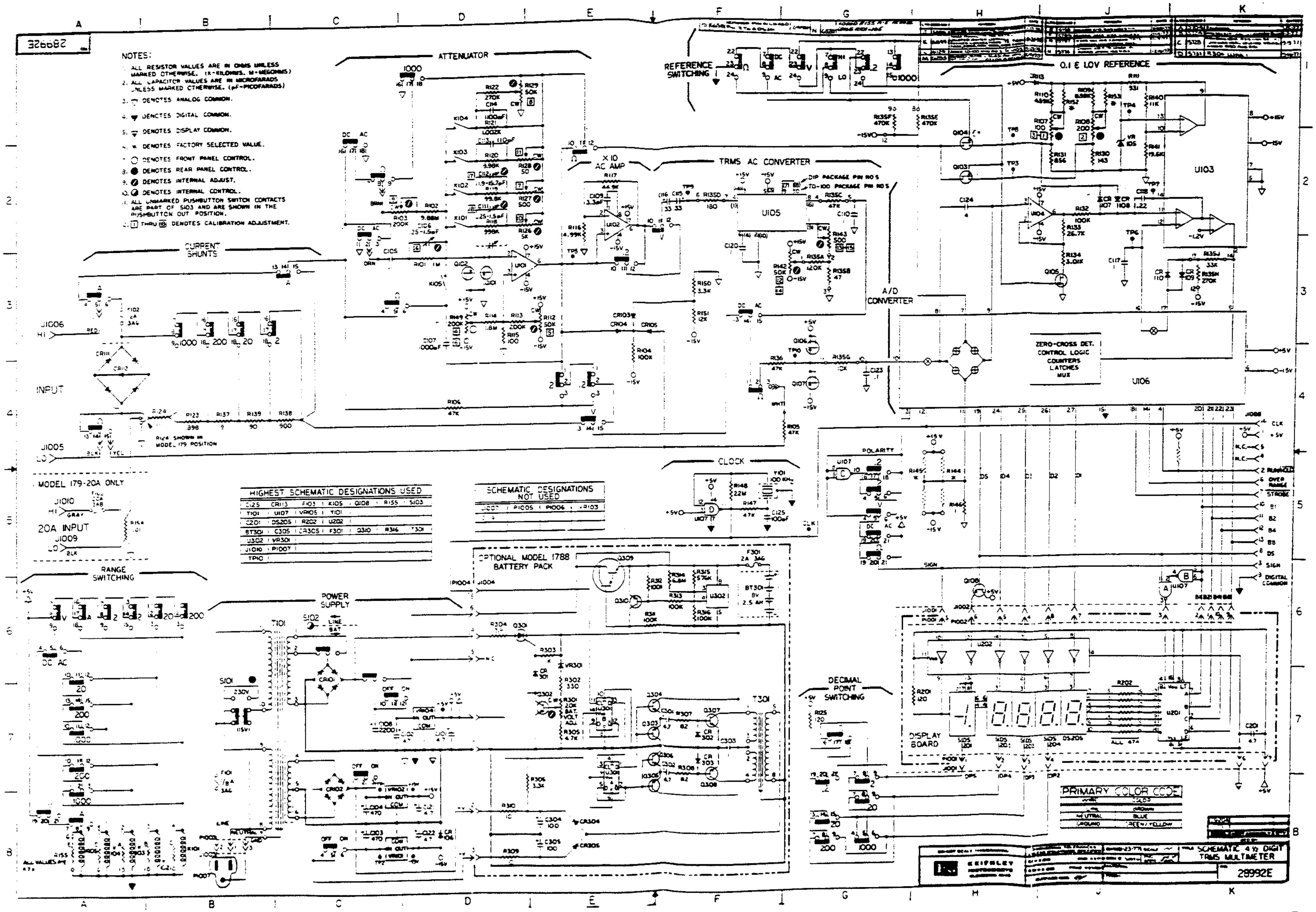
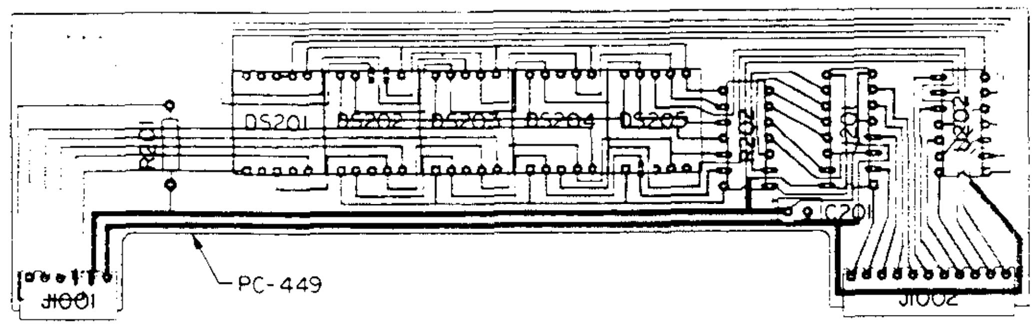


FIGURE 7-1. Schematic Diagram, Model 179 TRMS Multimeter.



CS-347-1
347-2

ITEM	PART NO	SCHEM DESIG	ZONE
1	28765C	HOLE SILK	C1
2	C-179-4.7	C201	F3
3	CS-348-1	J1001	B3
4	CS-348-2	J1002	F3
5	DD-16	DS202	D2
6	"	DS203	D2
7		DS204	D2
8	"	DS205	E2
9	DD-17	DS201	C2
10	IC-168	U201	F2
	IC-169	U202	F2
12	R-76-120	R201	C2
13	TF-64	R202	E2

DO NOT SCALE THIS DRAWING

KEITHLEY INSTRUMENTS

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED

MATERIAL

TITLE: COMPONENT LAYOUT PC-449

USED ON

C L6967

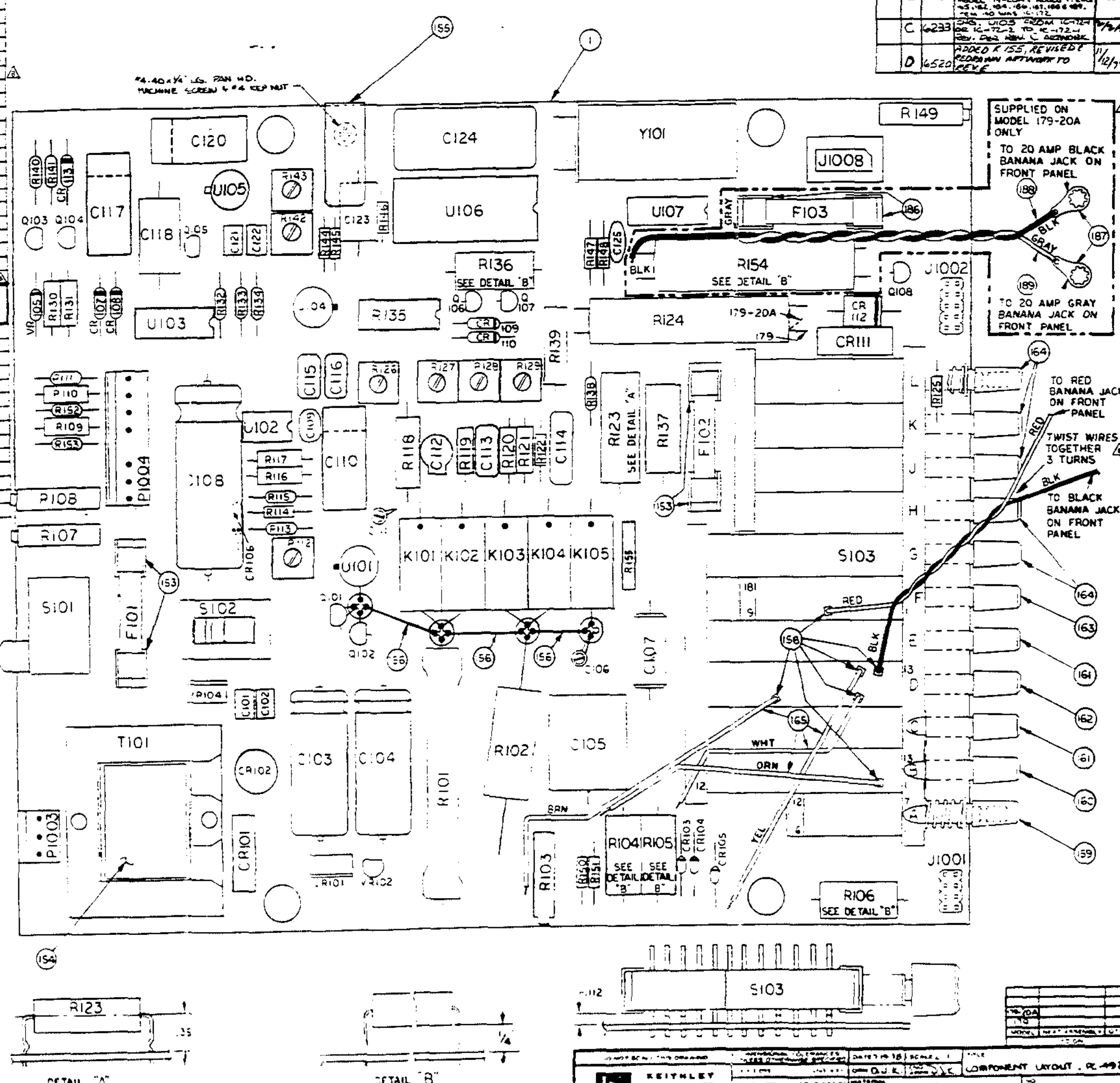
ITEM	PART NO.	SCHEM. DESIG.	ZONE
1	29696B	STAKING	
2	C-9-4.7	C101	D4
3	"	C102	D4
4	C-229-470	C103	E5
5		C104	E5
6	C-285-.1	C105	F5
7	C-184	C106	F4
8	C-38-1000	C107	F4
9	C-290-2200	C108	D3
10	C-291-3.3pF	C109	E3
11	C-294-1 OR C-296-1	C110	E3
12	C-184	C111	E3
13	C-254	C112	E3
14	C-278-110pF	C113	E3
15	C-278-1100pF	C114	F3
16	C-228-33	C115	E2
17	"	C116	E2
18	C-294-1 OR C-296-1	C117	D2
19	C-269-.22	C118	D2
20			
21	C-294-1 OR C-296-1	C120	D1
22	C-179-4.7	C121	D2
23	"	C122	E2
24	C-221-.1	C123	E2
25	C-294-4	C124	E1, F1
26	C-64-1000pF	C125	G2
27			
28			
29	RF-36	CR101	D5
30	RF-46	CR102	D5
31	RF-50	CR103	F5
32		CR104	F5
33	"	CR105	G5
34	RF-28	CR106	D3
35	"	CR107	D2
36		CR108	D2
37	"	CR109	F2
38	"	CR110	F3
39	RF-46	CR111	G2
40	RF-34	CR112	G2
41	RF-28	CR113	D2
42			
43			
44	FU-20	F101	D4
45	FU-13	F102	F2,3
46			
47			
48	CS-356-4	J1001	H5
49	CS-356-5	J1002	H2
50	SO-70	J1008	G2
51			
52	RL-56	K101	E4
53	"	K102	F4
54	RL-59	K103	F4
55		K104	F4
56		K105	F4
57			
58			
59	CS-288-3	P1003	D5
60	29467A	P1004	D3
61			
62			
63	TG-77	Q101	E4
64		Q102	E4
65		Q103	D2
66		Q104	D2
67		Q105	D2
68	TG-128	Q106	E2
69		Q107	F2
70	TG-47	Q108	G2
71			
72			
73	R-267-.1	R101	E4,5
74	R-265-9.89M	R102	E5
75	RP-89-200K	R103	F5
76	R-3-120K	R104	F5
77	R-3-47K	R105	F5
78		R106	G5
79	RP-[illegible]-4-[illegible]00	R107	D3
80	RP-64-200	R108	D3

ITEM	PART NO.	SCHEM. DESIG.	ZONE
81	R-263-8.98K	R109	D3
82	R-263-4.59K	R110	D3
83	R-88-931	R111	D3
84	RP-97-50K	R112	E3
85	R-88-200K	R113	E3
86	R-76-1.8M	R114	E3
87	R-88-100	R115	E3
88	R-263-4.99K	R116	E3
89	R-263-44.9K	R117	E3
90	R-264-998K	R118	E3
91	R-263-99.8K	R119	E3
92	R-263-9.98K	R120	F3
93	R-263-1.002M	R121	F3
94	R-76-270K	R122	F3
95	R-232-.898	R123	F3
96	R-262-.1000	R124	F2
97	R-76-120	R125	G3
98	RP-97-5K	R126	E3
99	RP-97-500	R127	E3
100	RP-97-50	R128	F3
101	RP-97-50K	R129	F3
102	R-263-143	R130	D2
103	R-263-856	R131	D2
104	R-88-100K	R132	D2
105	R-88-26.7K	R133	D2
106	R-88-3.01K	R134	E2
107	TF-65	R135	E2
108	R-3-47K	R136	F2
109	R-252-9.00	R137	F3
110	R-168-900	R138	F3
111	R-169-90	R139	F3
112	R-88-11K	R140	D2
113	R-88-19.6K	R141	D2
114	RP-97-50K	R142	E2
115	RP-97-500	R143	E2
116	R-76-* (SEL)	R144	E2
117	"	R145	E2
118	R-76-1	R146	E2
119	R-76-47K	R147	G2
120	R-76-22M	R148	G2
121	RP-89-200K	R149	G1
122	R-76-3.3K	R150	F5
123	R-76-12K	R151	F5
124	28798A (888-*)	R152	D3
125	"	R153	D3
126	TF-103-1	R155	F4
127			
128	SW-318	S101	D4
129	SW-397	S102	D4
130	27096B (SW-400)	S103	G4
131			
132			
133	TR-168 *	T101	D5
134			
135			
136	IC-165	U101	E4
137	IC-167	U102	E3
138	LSI-12	U103	D2
139	IC-175	U104	E2
140	IC-172-1	U105	D2
141	LSI-11	U106	E2
142	IC-102	U107	G2
143			
144			
145	IC-174 or IC-175	VR101	E5
146	IC-170	VR102	E5
147			
148	IC-93	VR104	D4
149	28798A (D258)	VR105	D2
150			
151			
152	CR-8	Y101	F1
153	FH-12	4 REQ'D	D4, F3
154	MC-221		D5
155	28776A		E1
156	#22 GA. BARE BUSS WIRE	3 REQ'D	E, F4
157			
158	LU-90	6 REQ'D	G4,5
159	29465C-3		H5
160	29465C-4		H5

ITEM	PART NO.	SCHEM. DESIG.	ZONE
161	29465C-6	2 REQ'D	H4,5
162	29465C-5		H4
163	29465C-7		H4
164	29465C-2	5 REQ'D	H3,4
165	SC-55 (COLOR ADJACENT TO SUIT SHOWN)	4 REQ'D	G4
166			
167			
168			
169			
170			
171			
172			
173			
174			
175			
176			
177			
178			
179			
180			
THE FOLLOWING ITEMS ARE SUPPLIED ON MODEL 179-20A ONLY			
181			
182	FU-47	F103	G2
183			
184	R-274-.01	R154	G2
185			
186	FH-12	2 REQ'D	H2
187	LU-92	2 REQ'D	H2
188	SC-80-0 (BLK)	LENGTH TO SUIT	H2
189	SC-80-8 (GRAY)	LENGTH TO SUIT	H2
190			

* NOTE:
FOR 100V JAPANESE VERSION SUBSTITUTE TR-169 FOR ITEM 133.
TR-168

ZONE	LTR	ECO NO	REVISION	DATE
	A	6099	RELEASED	[illegible]
	B	6129	[illegible] ADDED DETAIL "B" & NOTE TO TWIST WIRES AND REFERENCES TO MODEL 179-20A. ADDED ITEMS [illegible]	9-25-78
	C	6233	CHG. U105 FROM IC-172 OR IC-172-2 TO IC-172-1 REV. PER NEW C ARTWORK	[illegible]
	D	6520	ADDED R155, REVISED & REDRAWN ARTWORK TO REV E	11/12/79

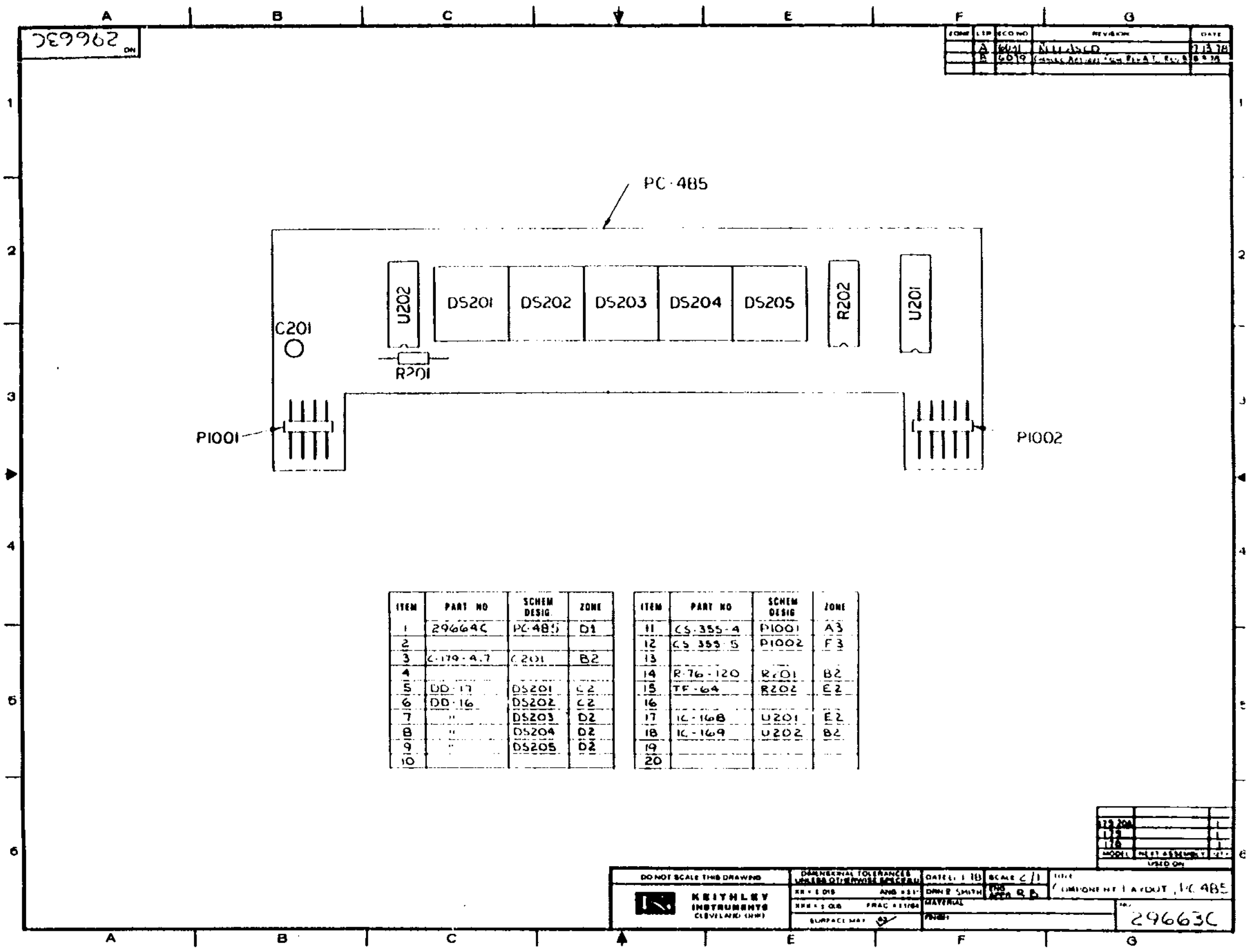


KEITHLEY INSTRUMENTS

COMPONENT LAYOUT, PC-492

29697 D

FIGURE 7-2. Component Layout, PC-492, Mother Board.

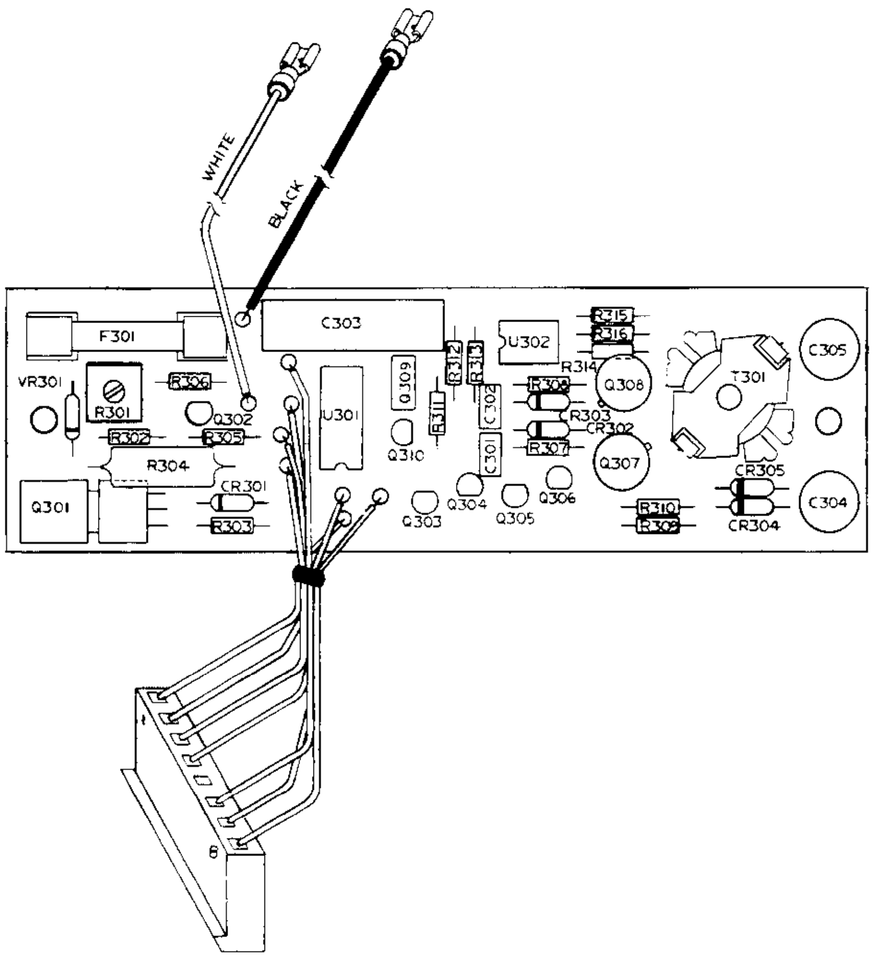


ITEM	PART NO	SCHEM DESIG	ZONE	ITEM	PART NO	SCHEM DESIG	ZONE
1	29664C	PC-485	D1	11	CS-355-4	P1001	A3
2				12	CS-355-5	P1002	F3
3	C-179-4.7	C201	B2	13			
4				14	R-76-120	R.OI	B2
5	DD-17	DS201	C2	15	TF-64	R202	E2
6	DD-16	DS202	C2	16			
7	"	DS203	D2	17	IC-168	U201	E2
8	"	DS204	D2	18	IC-169	U202	B2
9	"	DS205	D2	19			
10				20			

FIGURE 7-3. Component Layout, PC-485, Display Board.

ZONE	LTR.	ECO NO.	REVISION	DATE
	B	5731	REVISED & REDRAWN	9-16-77
	C	5759	ITEM 48 WAS 5TIK	9-28-77
	D	5797	ITEM 23 WAS 10K	11-10-77

ITEM	PART NO.	SCHEM. DESIG.	ZONE
1	29005C	HOLE SIZE	C2
2	C-179-4.7	C302	E3
3	"	C301	E3
4	C-256-1	C303	E3
5	C-295-100	C305	F3
6	"	C304	F4
7	CC-38-2	—	D4
8	CS-276	7 REQ'D	D5
9	CS-287-8	J1004	D5
10	DZ-61	VR301	C3
11	FH-12	—	C3
12	"	—	D3
13	FU-13	F301	C3
14	IC-103	U301	D3
15	LU-87	2 REQ'D	D2
16	R-76-10	R310	F4
17	"	R309	F4
18	R-76-82	R308	E3
19	"	R307	E3
20	R-76-330	R302	C3
21	R-76-1K	R303	D4
22	R-76-3.3K	R306	C3
23	R-76-4.7K	R305	D3
24	R-268-3.9	R304	D4
25	RP-97-20K	R301	C3
26	RF-28	CR301	D4
27	"	CR303	E3
28	"	CR302	E3
29	"	CR305	F4
30	"	CR304	F4
31	TG-47	Q302	C3
32	"	Q305	E4
33	"	Q304	E4
34	TG-53	Q306	E4
35	"	Q303	D4
36	TG-131	Q308	E3
37	"	Q307	E3
38	TG-132	Q301	C4
39	TR-170	T301	F3
40	22GA WIRE	7 REQ'D	D4
41	SC-76-0	—	D2
42	SC-76-9	—	D2
43	R-76-100K	R313	E3
44	"	R311	E3
45	"	R312	E3
46	R-76-6.8M	R314	E3
47	R-88-100K	R316	E3
48	R-88-576K	R315	E3
49	IC-177	U302	E3
50	TG-133	Q309	D3
51	TG-53	Q310	D3



1788			
MODEL	NEXT ASSEMBLY	QTY	
USED ON			

DO NOT SCALE THIS DRAWING

KEITHLEY INSTRUMENTS CLEVELAND OHIO

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: XX = ± .015, ANG = ± 1°, XXX = ± .005, FRAC = ± 1/64

SURFACE MAX

DATE 9-13-77 · SCALE 2-1 · DRN · APPR R.B. · MATERIAL · FINISH

TITLE: COMPONENT LAYOUT, PC-451

NO.

FIGURE 7-4. Component Layout, PC-451, Battery Pack Board.

KEITHLEY INSTRUMENTS, INC.
28775 AURORA ROAD
CLEVELAND, OHIO 44139

SERVICE FORM

MODEL NO.______ SERIAL NO.______ P.O. NO.______ DATE________ R-

NAME ______________________________ PHONE ____________

COMPANY ____

ADDRESS ______________________ CITY __________ STATE _____ ZIP ______

1. Describe problem and symptoms using quantitative data whenever possible (enclose readings, chart recordings, etc.) ______________________________

____

______________________ (Attach additional sheets as necessary).

2. Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also describe signal source.

3. List the positions of all controls and switches on both front and rear panels of the instrument. ______________________________

____

4. Describe input signal source levels, frequencies, etc. ______________________

____

____

5. List and describe all cables used in the experiment (length, shielding, etc.).

____

____

6. List and describe all other equipment used in the experiment. Give control settings for each. ______________________________

____

____

7. Environment:
   Where is the measurement being performed? (Factory, controlled laboratory, out-of-doors, etc.) ______________________________
   What power line voltage is used? ________ Variation? ____ Frequency? ______
   Ambient temperature? ________°F. Variation? ____°F. Rel. Humidity? ______
   Other ____

8. Additional Information. (If special modifications have been made by the user, please describe below.) ______________________________