STRUMENTI DEL LABORATORIO

Resistenze	General Radio 1432
	General Radio 1433
	General Radio 1434
	General Radio 1440
Divisore di Tensione	General Radio 1455
Condensatori	General Radio 1409
	General Radio 1412-BC
	General Radio 1423-A
	Danbridge DK4-SV
Induttori	General Radio 940
	Samar CI-E/1DC1
Generatori	HP 209A
	HP 33120A
	Hung Chang 8204A
Frequenzimetri	Bremi BRI 8200
	HP 5314A
Multimetri	Fluke 73
	Fluke 8000A
	Fluke 8050A
	Fluke 8840A
	Goldstar DM311
	Keithley 178
	Keithley DMM199
	LCR meter
Microvoltmetro selettivo	General Radio 1232A
Oscilloscopio	Tektronix 2205
Analizzatore di Spettro	SR770
Pila Campione	Tinsley 1268/241588

Type 1432 DECADE RESISTOR

Type 510 DECADE-RESISTANCE UNIT

FEATURES:
- ±0.025% accuracy. ■ Low thermal emf to copper.
- Low zero resistance. ■ Low temperature coefficient of resistance.
- Resistance increments, as well as total value, are always correctly indicated.
- Good frequency characteristics. ■ Residual reactances are small and known.
- Excellent stability. ■ Unaffected by high humidity.

USES: The Type 1432 Decade Resistors are primarily intended for precision measurement applications where their excellent accuracy, stability, and low zero resistance are important. They are convenient resistance standards for checking the accuracy of resistance measuring devices and are used as components in dc and audio-frequency impedance bridges. Many of the models can be used up into the radio frequency range. While they are also useful as substitution boxes for optimizing electronic circuitry, the less expensive Type 1434 Decade Resistors are recommended for such less exacting applications.

The individual decades (Type 510 Decade-Resistance Units) are available for applications requiring only one decade or as components to be built into experimental equipment, production test equipment, or commercial instruments.

DESCRIPTION: Each Type 510 Decade-Resistance Unit is enclosed in an aluminum shield, and a knob and etched-metal dial plate are supplied. The switch assemblies, less resistors, are also available as the Type 510-I and -P4L Switches.

The Type 1432 Decade Resistor is an assembly Type 510 Decade-Resistance Units in a single cabin Mechanical as well as electrical shielding of the uni and switch contacts is provided by the attracti aluminum cabinet and panel. The resistance elemen have no electrical connection to the cabinet and pan for which a separate shield terminal is provided.

Each decade has eleven contact studs and t resistors in series. All the contact studs in the lowe valued decades have a silver overlay to ensure stabili of resistance, and all the decades have a silver conta on the zero setting to give low and constant ze resistance.

Winding methods are chosen to reduce the effects residual reactances. The 1-, 10-, and 100-ohm steps u winding techniques that minimize inductance. The 0.0 and 0.1-ohm steps are straight wire and hairpin-shap ribbon respectively, and the high valued units a straight wound on mica forms.

SPECIFICATIONS

Long-Term Accuracy: ±0.025% for resistance settings on decades above 100 Ω per step. For lower resistance settings, see table. Our general two-year warranty applies to these tolerances unless the unit is damaged by excessive current. Tolerance shown applies to both resistance increments and total resistance after correction for zero resistance.

Maximum Current: The maximum current for each decade is given in the table below and also appears on the panel of each decade box and on the dial plate of each decade resistance unit.

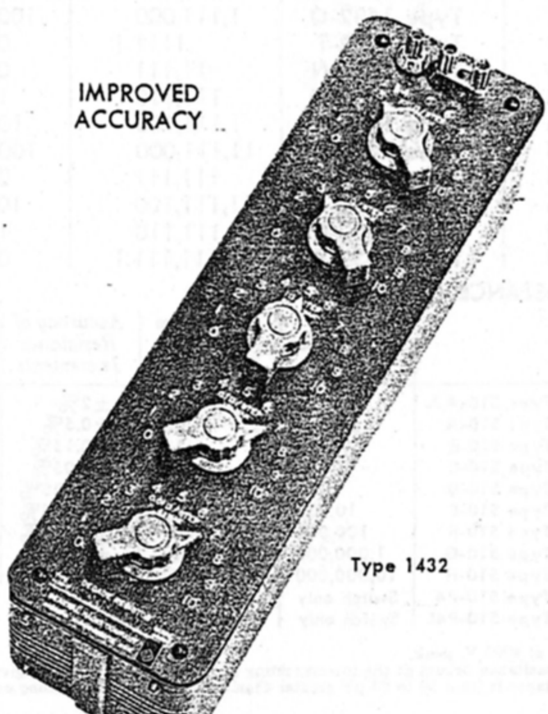
Frequency Characteristic: The accompanying plot shows the maximum percentage change in effective series resistance, as a function of frequency for the individual decade units. For low-resistance decades the error is due almost entirely to skin effect and is independent of switch setting, while for the high-resistance units the error is due almost entirely to the shunt capacitance and its losses and is approximately proportional to the square of the resistance setting.

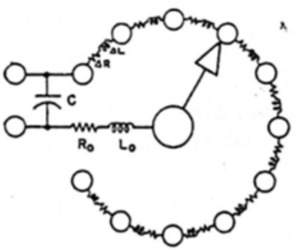
The high-resistance decades (Types 510-E, -F, -G, and -H) are very commonly used as parallel resistance elements in resonant circuits, in which the shunt capacitance of the decades becomes part of the tuning capacitance. The parallel resistance changes by only a fraction (between a tenth and a hundredth) of the series-resistance change, depending on frequency and the insulating material in the switch.

Characteristics of the Type 1432 Decade Resistors are simil to those of the individual Type 510 units, modified by the i creased series inductance, L_o, and shunt capacitance, C, due the wiring and the presence of more than one decade in tl assembly. At total resistance settings of approximately 10(ohms or less, the frequency characteristics of any of these deca resistors are substantially the same as those shown for the Ty 510 units. At higher settings, shunt capacitance becomes tl controlling factor, and the effective value of this capacitan depends upon the settings of the individual decades.

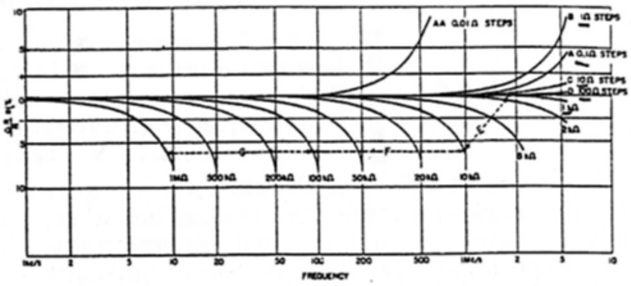
IMPROVED ACCURACY

Type 510


Type 1432



(Left) Equivalent circuit of a resistance decade, showing location and nature of residual impedances.



(Right) Maximum percentage change in series resistance as a function of frequency for Type 510 Decade-Resistance Units.

Typical Values of R_o, L_o, and C for the Decade Resistors:

Zero Resistance (R_o): 0.001 Ω per dial at dc; 0.04 Ω per dial at 1 Mc/s; proportional to square root of frequency at all frequencies above 100 kc/s.

Zero Inductance (L_o): 0.1 μH per dial.

Effective Shunt Capacitance (C): This value is determined largely by the highest decade in use. With the low terminal connected to shield, a value of 15 to 10 pF per decade may be assumed, counting decades down from the highest. Thus, if the third decade from the top is the highest resistance decade in circuit (i.e., not set at zero), the shunting terminal capacitance is 45 to 30 pF. If the highest decade in the assembly is in use, the effective capacitance is 15 to 10 pF, regardless of the settings of the lower-resistance decades.

Temperature Coefficient of Resistance: Less than ±10 ppm per degree C for values above 100 Ω and ±20 ppm per degree C for 100 Ω and below, at room temperatures. For the Type 1432 Decade Resistors, the box wiring will increase the over-all temperature coefficient of the 0.1- and 0.01-Ω decades.

Switches: Quadruple-leaf brushes bear on lubricated contact studs of ⅜-in diameter in such a manner as to avoid cutting but yet give a good wiping action. A cam-type detent is provided. There are eleven contact points (0 to 10 inclusive). The switch resistance is less than 0.0005 Ω. The effective capacitance is of the order of 5 pF, with a dissipation factor of 0.06 at 1 kc/s for the standard cellulose-filled molded phenolic switch form and 0.01 on the mica-filled phenolic form used in the Type 510-G and 510-H units.

Maximum Voltage to Case: 2000 V peak.

Terminals: For Type 1432, low-thermal-emf jack-top binding posts on standard ¾-in spacing. Shield terminal is provided. Type 510 units have soldering lugs.

Mounting: Type 1432, lab-bench cabinet Type 510, complete with dial plate, knob, template, and mounting screws.

Mechanical Data:

Type 1432	*Width*		*Height*		*Length*		*Net Wt*		*Ship Wt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
4-Dial	4⁵⁄₁₆	110	4¾	125	13	330	5¼	2.4	6	2.8
5-Dial	4⁵⁄₁₆	110	4¾	125	15¾	400	6¼	2.9	7	3.2
6-Dial	4⁵⁄₁₆	110	4¾	125	18¼	465	7½	3.5	9	4.1
Type 510	*Diameter*		*Depth Behind Panel*				*oz*	*kg*	*lb*	*kg*
	3¹⁄₁₆	78	3⁵⁄₁₆	85			11	0.4	2	1

DECADE RESISTORS

Catalog Number		*Total Ohms*	*Multiple of*	*No. of Dials*	*Type 510 Decades Used*
1432-9721	**Type 1432-U**	111.1	0.01 ohm	4	AA, A, B, C
1432-9711	**Type 1432-K**	1111	0.1	4	A, B, C, D
1432-9710	**Type 1432-J**	11,110	1	4	B, C, D, E
1432-9712	**Type 1432-L**	111,100	10	4	C, D, E, F
1432-9717	**Type 1432-Q**	1,111,000	100	4	D, E, F, G
1432-9720	**Type 1432-T**	1111.1	0.01	5	AA, A, B, C, D
1432-9714	**Type 1432-N**	11,111	0.1	5	A, B, C, D, E
1423-9713	**Type 1432-M**	111,110	1	5	B, C, D, E, F
1432-9716	**Type 1432-P**	1,111,100	10	5	C, D, E, F, G
1432-9725	**Type 1432-Y**	11,111,000	100	5	D, E, F, G, H
1432-9724	**Type 1432-X**	111,111	0.1	6	A, B, C, D, E, F
1432-9726	**Type 1432-Z**	11,111,100	10	6	C, D, E, F, G, H
1432-9702	**Type 1432-B**	1,111,110	1	6	B, C, D, E, F, G
1432-9723	**Type 1432-W**	11,111.1	0.01	6	AA, A, B, C, D, E

DECADE-RESISTANCE UNITS

Catalog Number		*Total Resistance Ohms*	*Resistance Per Step (ΔR) Ohms*	*Accuracy of Resistance Increments*	*Maximum Current 40° C Rise*	*Power Per Step Watts*	*ΔL μH*	*C** pF*	*L_o μH*
0510-9806	**Type 510-AA**	0.1	0.01	±2%	4 A	0.16	0.01	7.7–4.5	0.023
0510-9701	**Type 510-A**	1	0.1	±0.5%	1.6 A	0.25	0.014	7.7–4.5	0.023
0510-9702	**Type 510-B**	10	1	±0.15%	800 mA	0.6	0.056	7.7–4.5	0.023
0510-9703	**Type 510-C**	100	10	±0.05%	250 mA	0.6	0.11	7.7–4.5	0.023
0510-9704	**Type 510-D**	1000	100	±0.025%	80 mA	0.6	0.29	7.7–4.5	0.023
0510-9705	**Type 510-E**	10,000	1000	±0.025%	23 mA	0.5	3.3	7.7–4.5	0.023
0510-9706	**Type 510-F**	100,000	10,000	±0.025%	7 mA	0.5	9.5	7.7–4.5	0.023
0510-9707	**Type 510-G**	1,000,000	100,000	±0.025%	2.3 mA	0.5	—	7.7–4.5	0.023
0510-9708	**Type 510-H**	10,000,000	1,000,000	±0.025%	0.7* mA	0.5	—	13.5–5.0	0.023
0510-9604	**Type 510-P4**	Switch only	(Black Phenolic Frame)						
0510-9511	**Type 510-P4L**	Switch only	(Low-Loss Phenolic Frame)						

* Or a maximum of 4000 V, peak.
** The larger capacitance occurs at the lowest setting of the decade. The values given are for units without the shield cans in place. With the shield cans in place, the shunt capacitance is from 10 to 20 pF greater than indicated here, depending on whether the shield is tied to the switch or to the zero end of the decade.

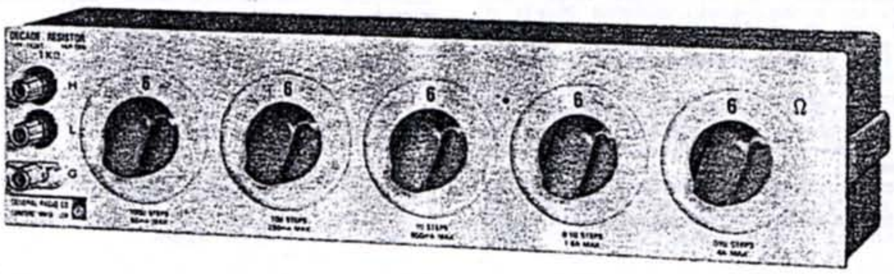
Form 1432-0103-F
October, 1966

Printed in U.S.A.

Type 1433 DECADE RESISTOR

- ±0.02% accuracy
- good frequency characteristics
- low temperature coefficient
- excellent stability
- low zero resistance

solo le decadi più significative: vedere la pag. seguente. (1) vedi



The 1433 Decade Resistors are primarily intended for precision measurement applications where their excellent accuracy, stability, and low zero resistance are important. They are convenient resistance standards for checking the accuracy of resistance-measuring devices and are used as components in dc and audio-frequency impedance bridges. Many of the models can be used up into the radio-frequency range. While they are also useful as substitution boxes for optimizing electronic circuitry, the less expensive Type 1434 Decade Resistors are recommended for such less exacting applications.

The individual decades (510 Decade-Resistance Units) are available for applications requiring only one decade or as components to be built into experimental equipment, production test equipment, or commercial instruments.

DESCRIPTION (2)

The 1433 Decade Resistor is an assembly of 510 Decade-Resistance Units in a single cabinet. Mechanical as well as electrical shielding of the units and switch contacts is provided by the attractive aluminum cabinet and panel. The resistance elements have no electrical connection to the cabinet and panel, for which a separate shield terminal is provided.

Each Type 510 Decade-Resistance Unit is enclosed in an aluminum shield, and a knob and etched-metal dial plate are supplied. Each decade has ten resistors in series; the contacts in the lower-valued decades have a silver overlay to ensure stability of resistance, and all the decades have a silver contact on the zero setting to give low and constant zero resistance. Winding methods are chosen to reduce the effects of residual reactances.

— See **GR Experimenter** for November-December 1968.

specifications

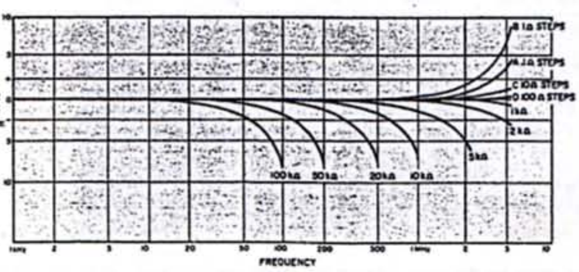
Long-Term Accuracy: Our two-year warranty applies to the tolerances given below unless the resistor is damaged by excessive current. These tolerances apply for low-current measurement at dc or low-frequency ac (see below).

Over-all Accuracy: The resistance difference between that at any setting and at the zero setting is equal to the indicated value ±(0.02% + 2 mΩ).

Incremental Accuracy: See table. This is the accuracy of the change in resistance between any two settings on the same dial.

Max Current: The max current for each decade is given in the table below and also appears on the panel of each decade box and on the dial plate of each decade resistance unit.

Frequency Characteristic: The accompanying plot shows the max percentage change in effective series resistance, as a function of frequency for the individual decade units. For low-resistance decades the error is due almost entirely to skin effect and is independent of switch setting, while for the high-resistance units the error is due almost entirely to the shunt capacitance and its losses and is approx proportional to the square of the resistance setting.



Max percentage change in series resistance as a function of frequency for Type 510 Decade-Resistance Units.

The high-resistance decades (510-E, -F, -G, and -H) are very commonly used as parallel resistance elements in resonant circuits, in which the shunt capacitance of the decades becomes part of the tuning capacitance. The parallel resistance changes by only a fraction (between a tenth and a hundredth) of the series-resistance change, depending on frequency and the insulating material in the switch.

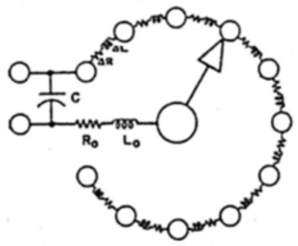
Characteristics of the 1433's are similar to those of the individual 510's modified by the increased series inductance, L_o, and shunt capacitance, C, due to the wiring and the presence of more than one decade in the assembly. At total resistance settings of approx 1000 ohms or less, the frequency characteristics of any of these decade resistors are substantially the same as those shown for the 510's. At higher settings, shunt capacitance becomes the controlling factor, and the effective value of this capacitance depends upon the settings of the individual decades.

Typical Values of R_o, L_o, and C for the Decade Resistors:

Zero Resistance (R_o): 0.001 Ω per dial at dc; 0.04 Ω per dial at 1 MHz; proportional to square root of frequency at all frequencies above 100 kHz.

Zero Inductance (L_o): 0.1 μH per dial + 0.2 μH.

Effective Shunt Capacitance (C): This value is determined largely by the highest decade in use. With the low terminal connected to the shield, a value of 15 to 10 pF per decade may be



Equivalent circuit of a resistance decade, showing location and nature of residual impedances.

assumed, counting decades down from the highest. Thus, if the third decade from the top is the highest resistance decade in circuit (i.e., not set at zero), the shunting terminal capacitance is 45 to 30 pF. If the highest decade in the assembly is in use, the effective capacitance is 15 to 10 pF, regardless of the settings of the lower-resistance decades.

Temperature Coefficient of Resistance: Less than ±10 ppm per degree C for values above 100 Ω and ±20 ppm per degree C for 100 Ω and below, at room temperatures. For the 1433's the box wiring will increase the over-all temperature coefficient of the 0.1- and 0.01-Ω decades.

Switches: Quadruple-leaf brushes bear on lubricated contact studs of ⅜-in. diameter in such a manner as to avoid cutting but yet give a good wiping action. A ball-on-cam detent is provided. There are eleven contact points (0 to 10 inclusive). The switch resistance is less than 0.0005 Ω. The effective capacitance is of the order of 5 pF, with a dissipation factor of 0.06 at 1 kHz for the standard cellulose-filled molded phenolic switch form and 0.01 on the mica-filled phenolic form used in the 510-G and 510-H units.

Max Voltage to Case: 2000 V pk.

Terminals: For 1433, low-thermal-emf jack-top binding posts on standard ¾-in. spacing; also provisions for rear-panel connections. Shield terminal is provided; 510's have soldering lugs.

Mounting: 1433's in lab-bench cabinet, rack models include mounting hardware; 510's complete with dial plate, knob, template, and mounting screws.

Dimensions and Weights: in. (mm), lb (kg):

	4-dial U, K, J, L, Q	5-dial T, N, M, P, Y	6-dial W, X, B, Z	7-dial F, G, H
Width*	12¼ (315)	14¾ (375)	17¼ (445)	
Height	3½ (89)			5¼ (135)
Depth	5 in. over-all, 4 in. behind panel			
Net Wt*	4¾ (2.2)	5¾ (2.7)	7 (3.2)	8¾ (4.0)
Ship. Wt*	5½ (2.5)	6½ (3.0)	8½ (3.9)	10¼ (4.7)

*Data given for bench models. All rack models same except 19 in. wide. Add approx 1 lb for rack-mount hardware.

Type 510's 3$\frac{1}{16}$ in. (78 mm) diameter, 3$\frac{5}{16}$ in. (85 mm) behind panel, 11 oz (0.4 kg) net weight.

Catalog Number Bench	Catalog Number Rack	Type	Total Ohms	Ohms per Step	No. of Dials	Type 510 Decades Used
1433-9700	1433-9701	1433-U	111.1	0.01	4	AA, A, B, C
1433-9702	1433-9703	1433-K	1111	0.1	4	A, B, C, D
1433-9704	1433-9705	1433-J	11,110	1	4	B, C, D, E
1433-9706	1433-9707	1433-L	111,100	10	4	C, D, E, F
1433-9708	1433-9709	1433-Q	1,111,000	100	4	D, E, F, G
1433-9710	1433-9711	1433-T	1111.1	0.01	5	AA, A, B, C, D
1433-9712	1433-9713	1433-N	11,111	0.1	5	A, B, C, D, E
1433-9714	1433-9715	1433-M	111,110	1	5	B, C, D, E, F
1433-9716	1433-9717	1433-P	1,111,100	10	5	C, D, E, F, G
1433-9718	1433-9719	1433-Y	11,111,000	100	5	D, E, F, G, H
1433-9720	1433-9721	1433-W	11,111.1	0.01	6	AA, A, B, C, D, E
1433-9722	1433-9723	1433-X	111,111	0.1	6	A, B, C, D, E, F
1433-9724	1433-9725	1433-B	1,111,110	1	6	B, C, D, E, F, G
1433-9726	1433-9728	1433-Z	11,111,100	10	6	C, D, E, F, G, H
1433-9729	1433-9730	1433-F	111,111.1	0.01	7	AA, A, B, C, D, E, F
1433-9731	1433-9732	1433-G	1,111,111	0.1	7	A, B, C, D, E, F, G
1433-9733	1433-9734	1433-H	11,111,110	1	7	B, C, D, E, F, G, H

Type 510 DECADE-RESISTANCE UNITS

Catalog Number	Type	Total Resistance Ohms	Resistance Per Step (ΔR) Ohms	Accuracy of Resistance Increments	Max Current 40° C Rise	Power Per Step Watts	ΔL µH	C** pF	L_o µH
0510-9806	510-AA	0.1	0.01	±2%	4 A	0.16	0.01	7.7–4.5	0.023
0510-9701	510-A	1	0.1	±0.4%	1.6 A	0.25	0.014	7.7–4.5	0.023
0510-9702	510-B	10	1	±0.1%	800 mA	0.6	0.056	7.7–4.5	0.023
0510-9703	510-C	100	10	±0.04%	250 mA	0.6	0.11	7.7–4.5	0.023
0510-9704	510-D	1000	100	±0.02%	80 mA	0.6	0.29	7.7–4.5	0.023
0510-9705	510-E	10,000	1000	±0.02%	23 mA	0.5	13	7.7–4.5	0.023
0510-9706	510-F	100,000	10,000	±0.02%	7 mA	0.5	70	7.7–4.5	0.023
0510-9707	510-G	1,000,000	100,000	±0.02%	2.3 mA	0.5	—	7.7–4.5	0.023
0510-9708	510-H	10,000,000	1,000,000	±0.02%	0.7* mA	0.5	—	7.5–4.5	0.023
0510-9604	510-P4	Switch only	(Black Phenolic Frame)						
0510-9511	510-P4L	Switch only	(Low-Loss Phenolic Frame)						

*Or a max of 4000 V, pk.

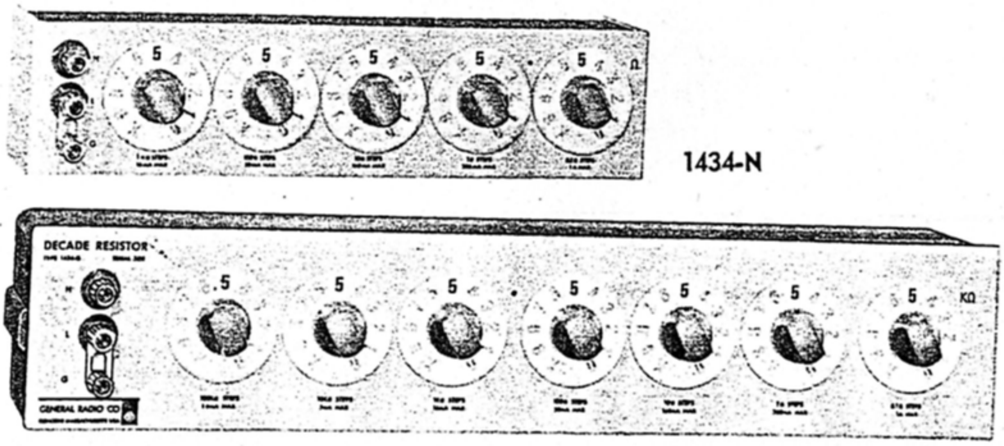
**The larger capacitance occurs at the highest setting of the decade. The values given are for units without the shield cans in place. With the shield cans in place, the shunt capacitance is from 0 to 20 pF greater than indicated here, depending on whether the shield is tied to the switch or to the zero end of the decade.

INSTRUCTIONS

Ferrarini

General Radio

TYPE 1434 DECADE RESISTORS



1434-N

1434-G

Figure 1. Type 1434-N and -G Decade Resistor boxes.

SPECIFICATIONS

Accuracy

Long-term: Two-year warranty applies to the tolerances given barring damage by excessive current. Tolerances apply at low currents and at dc or low-frequency ac.

Over-all: The resistance difference between that at any setting and at the zero setting is equal to the indicated value ±(0.05% + 5 mΩ).**

Incremental: See table. This is the accuracy of the change in resistance between any two settings of the same dial.

Zero Resistance: Approx 3 mΩ per dial at low frequencies except for the 1434-QC for which it is approx 30 mΩ.

Max Current: See table; these values also appear on the panel of each decade box. When this max current is passed through a decade, the temporary change in value will be less than the accuracy specification. Currents appreciably higher than this will cause permanent damage.

Total R of Decade	Resistance Per step	Incremental Accuracy*	Max Current	Inductance Per step
1 Ω	0.1 Ω	±3.0%	1 A	0.01 μH
10 Ω	1.0 Ω	±0.3%	0.3 A	0.05 μH
100 Ω	10 Ω	±0.08%	160 mA	0.08 μH
1 kΩ	100 Ω	±0.05%	50 mA	0.18 μH
10 kΩ	1 kΩ	±0.05%	16 mA	1.8 μH
100 kΩ	10 kΩ	±0.05%	5 mA	22.0 μH
1 MΩ	100 kΩ	±0.05%	1.6 mA	
100 Ω**	1 Ω/div	±1 Ω	200 mA	

*At low currents and low frequencies. **Except 1434-QC – add ±1 Ω if rheostat moved from zero.

Temperature Coefficient: <±10 ppm/°C at room temperature, except for the low-valued units where the +0.4%/°C temperature coefficient of the zero resistance must be added.

Frequency Characteristics: Generally similar to those of the 1433 Decades.

Switches: Multiple, solid-silver-alloy switches are used to obtain low and stable zero resistance.

Terminals: Jack-top binding posts on standard ¾-in. spacing. A shield terminal is also provided. The 1434-G has lug connections accessible from the rear.

Mounting: All types except the 1434-G are in small cabinets for bench use. The 1434-G is also designed for bench use but, with the addition of mounting hardware, becomes 3½-in. high, 19-in. relay-rack unit.

Mechanical Data:

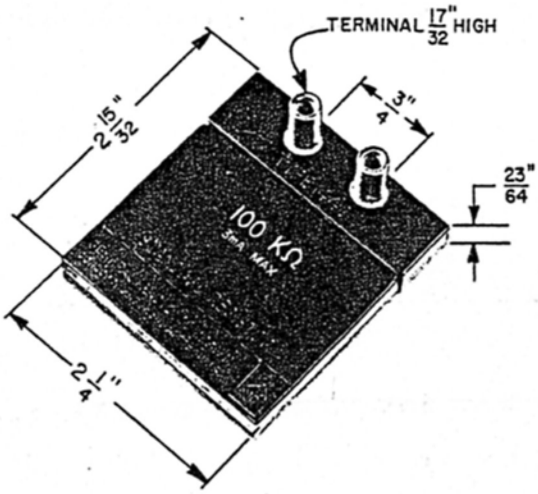
Models	Width		Height		Depth		Net Weight		Shipping Weight	
	in.	mm	in.	mm	in.	mm	lb	kg	lb	kg
M, N, P, QC	11¾	300	2¾	70	4⅛	110	3	1.4	4	1.9
B, X	13¾	350	2¾	70	4¼	110	3¼	1.5	4	1.9
G (bench)	17⅜	442	3½	89	5	130	6	2.8	7	3.2
G (rack)	19	485	3½	89	3½	89	6	2.8	7	3.2

Catalog Number	Description	Total Resistance (Ω)	Resistance Per Step	Number of Decades
	Decade Resistor			
1434-9714	**1434-N**	11,111	0.1 Ω	5
1434-9713	**1434-M**	111,110	1.0 Ω	5
1434-9716	**1434-P**	1,111,100	10 Ω	5
1434-9576	**1434-QC**	1,111,105	1 Ω/div	4 + rheostat
1434-9702	**1434-B**	1,111,100	1.0 Ω	6
1434-9724	**1434-X**	111,111	0.1 Ω	6
1434-9707	**1434-G**	1,111,111	0.1 Ω	7

General Radio Experimenter reference: Vol 39, No. 10, October, 1965

Type 1440 STANDARD RESISTOR

- accuracy ±0.01%
- stability ±10 ppm per year
- low thermal emf to copper



These extremely stable resistors are intended for use as laboratory or production standards for calibrating resistance bridges and for substitution measurements.

They are card-type, wire-wound resistors, carefully wound and adjusted. Low-temperature-coefficient Evanohm* wire is used for values above 10 ohms, manganin for the lower-resistance units. All units are heat cycled to reduce strains and are repeatedly checked to eliminate any that show abnormal behavior. They are encased in sealed, oil-filled, diallylphthalate boxes to promote long-term stability and to provide mechanical protection.

The 1440 resistors have low-thermal-emf binding posts and removable banana plugs to provide the four terminals necessary for accurate measurements at low values of resistance. A label on the reverse side lists initial calibration and date, space for future calibration data, and serial number.

— See **GR Experimenter** for October 1965.

* Registered trademark of the Wilbur B. Driver Company.

specifications

Accuracy: ±0.01% for all units except those of 1 Ω, which are ±0.02%. This accuracy is guaranteed for our standard warranty period of two years, unless the resistor has been damaged by excessive current. Measurements on the low-value units should be made with a four-terminal connection. All measurements at 23°C.

Calibration Accuracy: Resistors are calibrated by comparison, to a precision of ±20 ppm, with working standards whose absolute values are known typically to ±10 ppm as determined and measured in terms of reference standards periodically measured by the National Bureau of Standards. The measured deviation in % from nominal value, at 23°C and 0.01 watt, is entered on the label on the reverse side of the resistor.

Stability: Typically ±10 ppm per year.

Temperature Coefficient (Max): ±10 ppm/°C for resistances above 10 Ω; ±20 ppm/°C for 10 Ω and below.

Power Rating: 1 W. The corresponding current is indicated on the resistor and in the table below. This dissipation will cause a temperature rise of approx 25°C and a resulting temporary resistance change due to the temperature coefficient. If this rating is exceeded, permanent changes may result.

Residual Impedances: Approx shunt capacitance (2-terminal measurement), 2.5 pF; less for 3-terminal measurement. Typical series inductance, see table.

Approx Frequency Characteristic: See table.

Terminals: Gold-plated jack-top copper binding posts (¾-in. spacing) with banana plugs that are removable and can be replaced by 6-32 screws for installation of soldering lugs.

Dimensions (less terminals): 2¼ x 2 15/32 x 13/32 in. (58 x 64 x 10 mm).

Net Weight (approx): 2 oz (60 g).

Catalog Number	Resistance	Max Current	Typical Inductance	Approx Frequency for 0.1% Resistance Change	
				Series R	Parallel R
1440-9601	1 Ω	1.0 A	0.12 μH	300 kHz	30 kHz
1440-9611	10 Ω	310 mA	0.13 μH	1 MHz	300 kHz
1440-9621	100 Ω	100 mA	0.20 μH	3 MHz	1 MHz
1440-9631	1 kΩ	30 mA	2.5 μH	2 MHz	1 MHz
1440-9641	10 kΩ	10 mA		200 kHz	1 MHz
1440-9651	100 kΩ	3 mA		20 kHz	100 kHz
1440-9661	1 MΩ	1 mA		2 kHz	10 kHz

Units of 0.1 Ω and 0.01 Ω, as well as other special values, available on request.

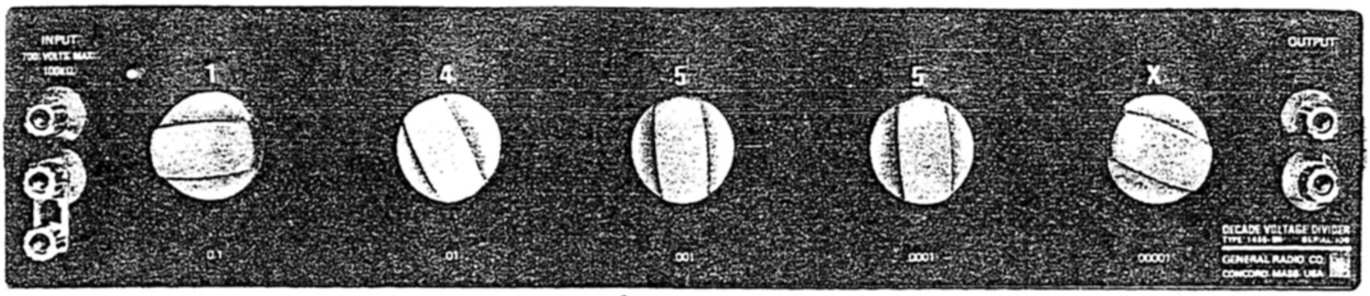


Figure 1-1. The Type 1455-BH Decade Voltage Divider.

SPECIFICATIONS

Type:	**1455-AH**	**—A**	**—AL**	**—BH**	**—B**
Dials:	4	4	4	5	5
Input Resistance:	100 kΩ	10 kΩ	1 kΩ	100 kΩ	10 kΩ
Input Voltage Rating: May be 20 ppm linearity change at full rating (see below)	700 V	230 V	70 V	700 V	230 V
Frequency Response (f_o at 3 dB down): (unloaded, at max output resistance setting)	85 kHz	850 kHz	7.5 MHz	69 kHz	690 kHz
Resolution (in ppm of input):	100	100	100	10	10
Linearity					
Absolute Linearity (in ppm of input): Output taken with respect to output zero setting at low audio frequencies with input voltage < ½ rating.					
Ratio					
0.00001 to 0.00010	—	—	—	± 0.02	± 0.03
0.00010 to 0.00100	± 0.2	± 0.3	± 0.7	± 0.2	± 0.3
0.00100 to 0.01000	± 2	± 2	± 3	± 2	± 2
0.01000 to 0.10000	±15	±15	±20	±10	±10
0.10000 to 1.00000	±30	±30	±50	±20	±20
Terminal Linearity (in ppm of input) (add to absolute linearity):					
Four-terminal (output with respect to low output terminal):	± 0.004	± 0.04	± 0.4	± 0.004	± 0.04
Three-terminal (low terminals common, or output with respect to low input terminal):	± 0.02	± 0.2	± 2	± 0.02	± 0.2
Max Output Resistance: (input shorted)	27.9 kΩ	2.79 kΩ	333 Ω	28.8 kΩ	2.88 kΩ
Effective Output Capacitance: (typical, unloaded)	67 pF	67 pF	67 pF	80 pF	80 pF

Frequency Characteristic:

Acts like simple RC circuit below f_o so that

$$\frac{E_o}{E_{in}} \approx \frac{\text{reading}}{\sqrt{1+\left(\frac{f}{f_o}\right)^2}}.$$

Tabulated value of f_o is at setting that gives max output resistance so that f_o at all other settings is higher. At $0.044 f_o$, response is down < 0.1%.

Accuracy of Input Resistance: +0.015%, except for 1455-AL, which is +0.025%.

Temperature Coefficient: < 20 ppm for each resistor. Since voltage ratios are determined by resistors of similar construction, net ambient temperature effects are very small.

Dimensions (width × height × depth): Rack models, 19 × 3½ × 4⅝ in. (485 × 89 × 120 mm); 4-dial bench models, 14¾ × 3½ × 6 in. (375 × 89 × 155 mm); 5-dial bench models, 17$\frac{15}{16}$ × 3½ × 6 in. (455 × 89 × 155 mm).

Net Weight: Bench models, 4-dial, 6¾ lb (3.1 kg); 5-dial, 7¾ lb (3.6 kg).

Shipping Weight (est): Bench models, 4-dial, 7½ lb (3.5 kg); 5-dial, 8½ lb (3.9 kg).

Add approx 1 lb (0.5 kg) to net and shipping weights for rack models.

INTRODUCTION

1.1 PURPOSE.

The Type 1455 Decade Voltage Divider is a convenient means of obtaining accurately known voltage ratios. Among its many uses are the calibration of voltmeters, linearity measurements on continuously adjustable transformers and potentiometers, measurement of gain and attenuation, the precise measurement of frequency-response characteristics of audio-frequency networks, and the determination of turns ratios in transformers.

Five models are available in order to provide a choice in resolution and impedance level. The high-impedance models, Types 1455-AH and -BH, permit greater applied voltage (up to 700 V), while the lowest-impedance model, Type 1455-AL, has useful accuracy in the radio-frequency range.

1.2 DESCRIPTION.

These voltage dividers are housed in a 3 1/2"-high cabinet. All models are available for either bench use or for installation in a relay rack. Refer to Table 1-1.

The panel binding posts are for general use, and connection to the instrument may also be made at the rear, as is often preferred for rack-mounted equipment.

The Types 1455-AH, -A, and -AL have four selector switches for four-digit readout. The Types 1455-BH and -B have five decade switches for five-digit readout. These switches indicate the voltage-ratio setting in an in-line readout with the decimal point always before the first digit (refer to paragraph 2.3).

1.3 ACCESSORIES AVAILABLE.

Panel-Adaptor Sets are supplied with the Type 1455 relay-rack models listed in Table 1-1. Panel-Adaptor Sets are also available for mounting Type 1455 bench instruments in a standard 19-inch relay rack (refer to Table 1-2).

Refer to the Appendix for details on other equipment recommended for use with the Type 1455 Decade Voltage Dividers.

Table 1-2
TYPE 1455 PANEL-ADAPTOR SETS

Catalog Number	*Description*
0480-2070	Panel-Adaptor Set for Types 1455-A, -AH, and -AL.
0480-2010	Panel-Adaptor Set for Types 1455-B and -BH.

Table 1-1
TYPE 1455 DECADE VOLTAGE DIVIDERS

Catalog Number				
Bench	*Relay Rack*	*Type*	*No. of Decades*	*Ratio Range*
1455-9700	1455-9701	1455-A	4	0.0001 to 1.0
1455-9702	1455-9703	1455-AH	4	0.0001 to 1.0
1455-9704	1455-9705	1455-AL	4	0.0001 to 1.0
1455-9706	1455-9707	1455-B	5	0.00001 to 1.0
1455-9708	1455-9709	1455-BH	5	0.00001 to 1.0

OPERATING PROCEDURE

2.1 INSTALLATION.

To install a Type 1455 Decade Voltage Divider in a standard 19-inch relay rack using the appropriate Panel-Adaptor Set, refer to Figure 2-1 and proceed as follows:

a. Remove the black nylon buttons from the holes in the side panels of the instrument. These buttons are press fitted and are easily removed with a small screwdriver.

b. Install the adaptor panel (A) on each side of the instrument, using the 3/8-inch locking screws (B) supplied. The holes in the side panels are tapped to receive these screws.

c. Mount the assembly in a standard 19-inch relay-rack cabinet, using the 5/8-inch No. 10-32 screws (C) and nylon washers (D) supplied.

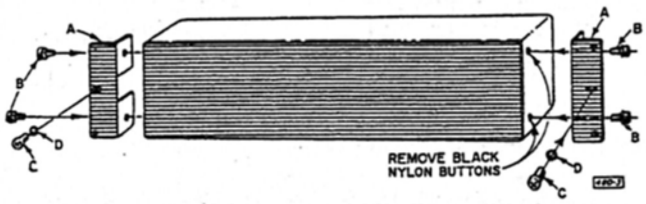


Figure 2-1. Relay-rack installation of a Type 1455 Decade Voltage Divider.

2.2 CONNECTIONS.

2.2.1 FRONT-PANEL CONNECTIONS.

Connect the external voltage source to the two insulated INPUT terminals. If grounded operation is to be used, connect the ground link between the lower INPUT grounded terminal and the middle (insulated) terminal. Connect the device to be supplied to the OUTPUT terminals.

2.2.2 REAR CONNECTIONS.

To make connections at the rear of the instrument, refer to Figure 2-2 and proceed as follows:

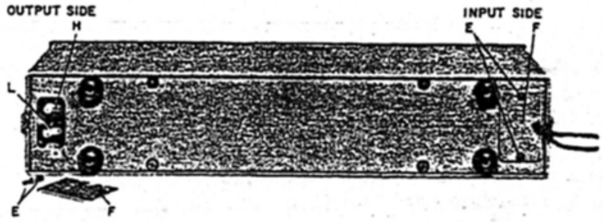


Figure 2-2. Rear view of Type 1455 showing OUTPUT terminals and INPUT side fully connected.

a. Remove the two 6-32 screws (E) and the small rectangular plate (F) from the INPUT side of the rear panel. (The terminals on the front panel, except for the lower INPUT grounded terminal, extend directly to the rear and are available for connection when the rear plates are removed.)

b. Connect the voltage source to the recessed INPUT terminals at the rear. If grounded operation is desired, connect the ground link between the lower INPUT grounded terminal and the middle (insulated) terminal on the front panel.

c. Remount plate (F) on the rear panel, using the two screws (E) previously removed.

NOTE

In order to provide an opening for the connection leads, plate (F) must be mounted with its slot facing toward the side panel of the instrument. To seal the instrument from outside dust and dirt when connections are not required at the rear, mount plate (F) with its slot facing away from the side panel.

d. At the OUTPUT side of the rear panel, repeat step a above, connect the device to be supplied to the rear OUTPUT terminals (H and L), and remount plate (F) as described in step c.

2.3 OPERATION.

Remember that the voltage divider, like any potentiometer, should be used only with high resistance loads. Refer to paragraph 2.7.

Set the selector switches to indicate the desired voltage ratio. When setting the switches remember that X = 10, and the decimal point is always placed before the first digit. For example, if the output voltage is to be 0.1240 times the input voltage, the switches can be set (from left to right, respectively) to:

1, 2, 4, 0 = 0.1240

or

1, 2, 3, X = 0.1240

And if a ratio of 1.0000 is desired, set the switches to:

9, 9, 9, X = 1.0000

2.4 TYPICAL USES.

2.4.1 CALIBRATION OF A VTVM.

The simple circuit of Figure 2-3 is useful for checking electronic, low-frequency ac or dc voltmeters which have an input impedance much higher than the output impedance of the divider. The Type 1455-AL is particularly useful for low-voltage ac calibration because of its lower output impedance and better frequency characteristics. In this circuit, the standard meter should be used with a reading near full scale to obtain the best accuracy.

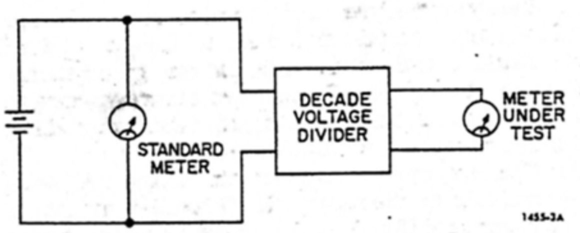


Figure 2-3. Circuit for vacuum-tube voltmeter calibration and test, using a Type 1455 Decade Voltage Divider.

2.4.2 LINEARITY CHECKS OF POTENTIOMETERS.

The linearity of potentiometers and other voltage dividers can be checked using the circuits shown in Figure 2-4 and Figure 2-5. Both circuits are essentially Wheatstone bridges.

The circuit of Figure 2-4 is preferable if the potentiometer or divider under test has a resistance higher than that of the divider.

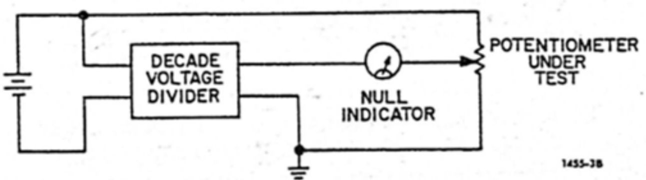


Figure 2-4. Type 1455 Decade Voltage Divider in null circuit used for linearity test of a high-resistance potentiometer.

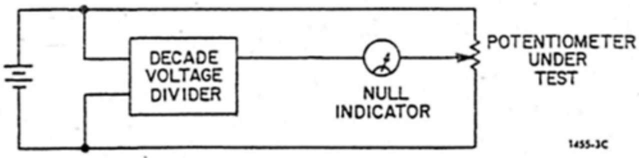


Figure 2-5. Null circuit for linearity test of a low-resistance potentiometer, using a Type 1455 Decade Voltage Divider.

The circuit of Figure 2-5 is preferable if the impedance of the device under test is lower than that of the divider. In either of these circuits, when the divider is adjusted to give a null indication, no current is drawn from the divider and the open-circuit calibration is correct.

These circuits may also be useful at audio frequencies, but capacitive-loading effects must be considered in order to obtain a null, and to obtain the desired accuracy at a null. The null detector should either be battery-operated and floating (GR 1232 Tuned Amplifier and Null Detector) or isolated from the circuit by a shielded transformer (GR 578 Shielded Transformer). In either case, the larger output capacitance should be placed across the device with the lower output impedance in order to reduce loading and phase-shift errors. It may be necessary to add additional capacitance to obtain a null.

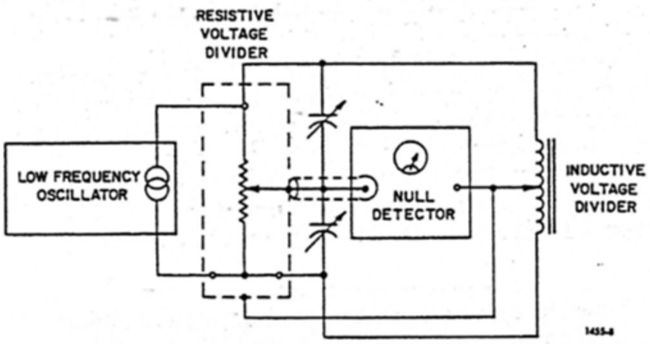


Figure 2-6. An ac null circuit for linearity test of an inductive voltage divider, using a resistive (Type 1455) voltage divider.

An example of an ac circuit is shown in Figure 2-6. Here, the transformer-type divider has a much lower output impedance than that of the resistive divider, so that the low-side of the detector and the case of the resistive divider are both tied to the output.

2.5 EFFECTS OF TEMPERATURE.

Since all resistors are of similar construction and have more or less equal temperature coefficients, the effects of changes in ambient temperature are very small. The effects from self-heating are not balanced out, however. In Figure 3-1, note that in the first decade between contacts 7 and 9, which are bridged by the second decade, only half of the input current is carried. The resistors between these points will have only one-quarter of the temperature rise of other resistors in the decade, causing an error in the output voltage. The temperature rise of the following decades is negligible. The temperature effect is greatest at the zero position of the first decade.

To keep the self-heating error at the first decade within specifications, limit the input voltage to the divider to one-half of the maximum voltage rating.

In dc measurements at very low levels, substantial error can result from thermal emf's at the junctions of dissimilar metals. The Type 1455 Decade Voltage Dividers use gold-plated copper binding posts to minimize these voltages when connections are made with copper wire.

2.6 FREQUENCY RESPONSE.

The Type 1455 Decade Voltage Dividers act very much like simple RC low-pass filters at frequencies below their 3-dB cutoff frequency (f_o). Thus, attenuation at any frequency below f_o can be determined from the expression:

$$\frac{E_{out}}{E_{in}} = \frac{N}{\sqrt{1 + \left(\frac{f}{f_o}\right)^2}}$$

where:

N = divider setting
f = operating frequency

In the specifications, the value of f_o is given for the setting which gives the maximum output resistance (refer to paragraph 2.7), with no additional capacitance on the OUTPUT terminals, and with the case connected to the low INPUT terminal. For any other setting, f_o is higher, and additional capacitance on the output will reduce f_o which is inversely proportional to $R_{out} \times C_{out}$. The effective internal-loading capacitance is also given in the specifications to facilitate the calculation of values of f_o when external capacitance is added.

In some measurement circuits, such as the circuit shown in Figure 2-6, it is possible to connect the divider case to a voltage equal to the output voltage. This greatly reduces the effect of stray capacitance and makes it possible to obtain extremely precise ac measurements even with the high-resistance models (Types 1455-AH and -BH).

At settings near zero, the inductance of the wiring (approximately 0.7 μH) introduces a small error which is proportional to frequency and is equal to approximately 0.1 ppm at 10 kHz.

2.7 OUTPUT RESISTANCE.

The decimal ratio in the Type 1455 dividers is the ratio of the open-circuit output voltage to the input voltage. The divider is intended primarily for use with high-impedance loads, such as a null indicator or high-impedance voltmeter. For finite load resistances, it is necessary to know the output resistance in order to determine the actual output voltage of the divider. The loaded output voltage (E_o) can be determined by the expression:

$$E_o = N \frac{R_L}{R_L + R_o}$$

where:

N = divider setting
R_L = load resistance
R_o = output resistance

To the first approximation, the output resistance is that of a simple divider (see Figure 2-7). For this circuit, with the input shorted, the output resistance (R_o) is:

$$R_o = N(1-N)R_{in}$$

where:

N = divider setting
R_{in} = input resistance

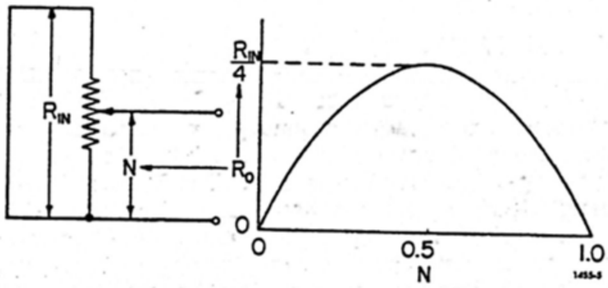


Figure 2-7. Output-resistance characteristic of a simple divider.

Actually, the Type 1455 divider circuit is substantially more complicated than a simple divider; and the actual output resistance for any given setting is difficult to calculate. Output resistance values for combinations of the first two digits (with other digits set at zero) are given in Table 2-1 for Type 1455-A and -B. The output resistance values for the Types -AH and -BH are those given in Table 2-1 but multiplied by a factor of 10. For the Type 1455-AL, multiply by 0.1.

Note that it is not possible to interpolate between values given in Table 2-1. The resistance is always increased if subsequent digits are set to other than

Table 2-1
OUTPUT RESISTANCE* FOR TYPES 1455-A, -B

Second Selector – Switch Setting

First Selector – Switch Setting	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0	0	189	356	501	624	725	804	861	896	909
0.1	900	1069	1216	1341	1444	1525	1584	1621	1636	1629
0.2	1600	1749	1876	1981	2064	2125	2164	2181	2176	2149
0.3	2100	2229	2336	2421	2484	2525	2544	2541	2516	2469
0.4	2400	2509	2596	2661	2704	2725	2724	2701	2656	2589
0.5	2500	2589	2656	2701	2724	2725	2704	2661	2596	2509
0.6	2400	2469	2516	2541	2544	2525	2484	2421	2336	2229
0.7	2100	2149	2176	2181	2164	2125	2064	1981	1876	1749
0.8	1600	1629	1636	1621	1584	1525	1444	1341	1216	1069
0.9	900	909	896	861	804	725	624	501	356	189

*Values given are for combinations of settings for first two digits, with other digits set at zero.

zero. The highest output resistance (given in the specifications) is at settings 5455 for the four-digit dividers, and 54545 for the five-digit models. Output resistance for other settings may be most easily found by resistance measurement.

If the generator has a finite impedance, and the voltage is measured before this impedance instead of at the divider, the ratio with respect to this generator voltage will be in error. However, if the load impedance is infinite, the ratio of any two settings will be correct because the input impedance of an unloaded divider of this type is constant.

If both the generator and load impedances are finite and relative ratios are desired, the equivalent output impedance should be measured with the INPUT terminals connected through an impedance equal to that of the generator, and corrections should be made as shown above.

SECTION 3

PRINCIPLES OF OPERATION

3.1 CIRCUIT DESCRIPTION.

The method of voltage division, which is attributed to Kelvin and Varley, is shown by the schematic diagram for the Type 1455-A, Figure 3-1. Eleven equal resistors are used in all but the last decade. Two of these resistors are shunted by the next decade which uses resistors of one-fifth the value of those in the preceding decade. In this manner, each decade effectively becomes a string of ten equal resistors giving the desired decimal readout on the dial.

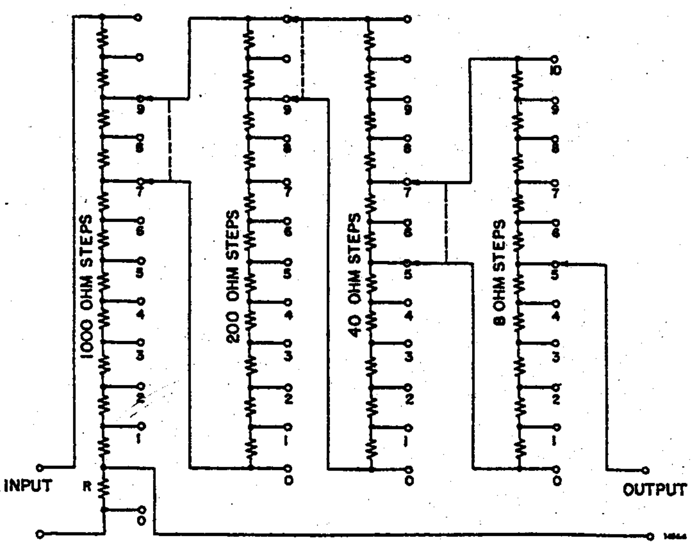


Figure 3-1. Elementary schematic diagram of Type 1455-A Decade Voltage Divider.

The Type 1455-AH uses resistors of ten times the values shown in Figure 3-1. On the Types 1455-AL, -B, and -BH, additional fixed resistors are added across the input of the later decades in order to avoid the necessity of using very low-value resistors which would be less accurate and stable.

3.2 INTERPRETATION OF LINEARITY SPECIFICATIONS.

3.2.1 LINEARITY AND ACCURACY.

The linearity specification for the Type 1455 is given in ppm (parts-per-million) of the input voltage. This specification is similar to a voltmeter accuracy specification given in percent-of-full scale. At any setting, the difference between the output voltage and the input voltage multiplied by the setting will be less than the specified ppm of the input voltage.

In terms of percentage of setting, the accuracy is equal to the specified linearity divided by the setting. Because the setting is never greater than unity, the accuracy, as a percent of setting, is always a larger number than the linearity specification. For very low settings the linearity, as a fraction of input, becomes a very small number. The accuracy, as a percent, of these low settings is actually poorer than that of higher settings, because somewhat lower tolerance resistors are used on the higher digits.

3.2.2 ABSOLUTE LINEARITY.

For very low settings, the resistance of the wiring and switches add small, but noticeable errors, because at the zero setting the output is not exactly zero. This error can be ignored if the output at any setting is taken with respect to the actual output voltage at the zero setting. This is shown in Figure 3-2 where the errors are greatly exaggerated for the purpose of illustration. Here, the output voltage at zero setting is substantial. Also, the output at full scale does not equal the input. Absolute linearity is a measure of how far the output voltage differs from a straight line drawn between the output voltages at the zero and full-scale settings, even though the voltages at these points are not exactly equal to zero and unity.

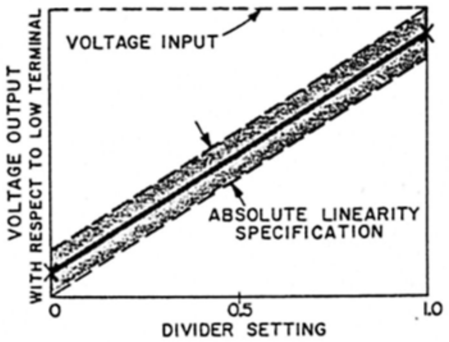


Figure 3-2. Exaggerated illustration of absolute linearity of a Type 1455.

An example of the use of absolute linearity is the calibration of dividers using lead-compensation correction as in Figure 3-3. Here, potentiometers A and B are adjusted so that the 0 (zero) and 1 (one) settings of both dividers coincide.

3.2.3 TERMINAL LINEARITY.

The linearity of a voltage actually present at two terminals of a divider is called the terminal linearity.

When the output is taken across both OUTPUT terminals, all four divider terminals are in use. An example of a measurement using this four-terminal connection is shown in Figure 2-3. The error due to switch resistance (refer to paragraph 3.2.2) is compensated for when such a measurement is made. A small resistor (R, Figure 3-1) is added in series with the divider so that the low OUTPUT terminal is at very nearly the same voltage as the high OUTPUT terminal when the divider setting is at zero. This resistor is of the order of 0.001 Ω and it will not affect calibration of the divider.

In some cases, the input and output connections must be tied together, or the output must be taken with respect to the low INPUT terminal. In such three-terminal applications, the compensating resistor (R, Figure 3-1) is not effective and an additional error is given in the specifications under Terminal Linearity. Examples of three-terminal operation are the comparison of two dividers and checking the linearity of potentiometers using the circuit shown in Figure 2-6. However, if the potentiometer under test is of high resistance (greater than the input resistance of the divider), there will be less error if it is connected to the low OUTPUT terminal of the divider as shown in Figure 2-4.

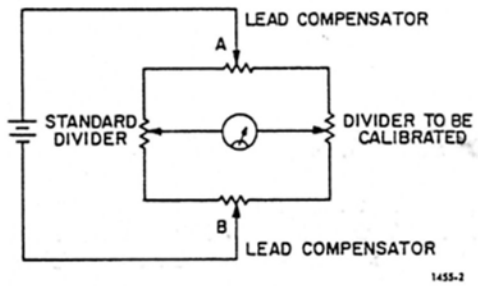
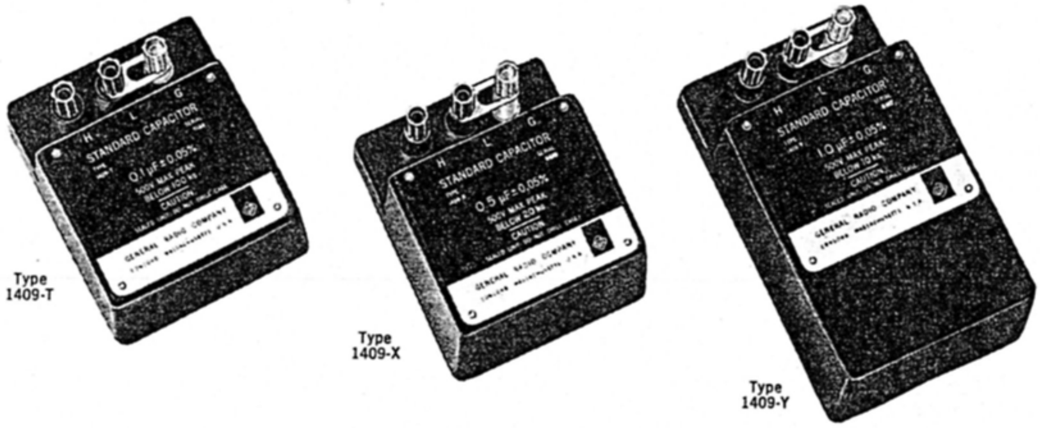


Figure 3-3. Divider calibration, using lead-compensation circuit.

Type 1409 STANDARD CAPACITOR

- 0.001 to 1 μF
- ±0.01%/year stability
- calibration accuracy ±0.02%
- two- and three-terminal calibration provided



Type 1409-T

Type 1409-X

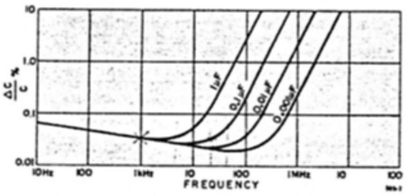
Type 1409-Y

The 1409 Standard Capacitors are fixed mica capacitors of very high stability for use as two- or three-terminal reference or working standards in the laboratory.

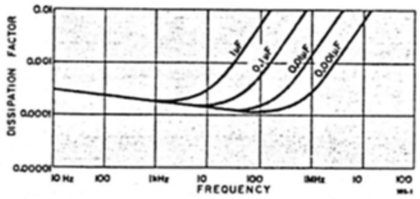
Typical capacitors, observed over more than 12 years, have shown random fluctuations of less than ±0.01% in measured capacitance with no evidence of systematic drift.

These capacitor units consist of a silvered-mica and foil pile, spring-held in a heavy metal clamping structure for mechanical stability. The units are selected for low dissipation factor and are stabilized by heat cycling. They are housed, with silica gel to provide continuous desiccation, in cast aluminum cases, sealed with high-temperature potting wax. A well is provided in the wall of the case for the insertion of a dial-type thermometer. Three jack-top binding posts are provided on the top of the case and removable plugs on the bottom, for convenient parallel connection without error.

— See **GR Experimenter** for July 1957 and October 1960.



(Left) Change in capacitance as a function of frequency for typical Type 1409 Capacitors. The 1-kHz value on the plot should be used as a basis of reference in estimating frequency errors. (Right) Dissipation factor as a function of frequency.



specifications

Adjustment Accuracy: Within ±0.05% of the nominal capacitance value (two-terminal) marked on the case. Accuracy is guaranteed for two years under the terms of our standard warranty if the capacitor has not been damaged by excessive current or voltage.

Calibration: A certificate of calibration is supplied with each unit, giving both two- and three-terminal measured capacitances at 1 kHz and at a specified temperature. The measured value is the capacitance added when the standard is plugged directly into General Radio binding posts. This value is obtained by comparison, to a precision better than ±0.01%, with working standards whose absolute values are known to an accuracy typically ±0.01%, determined and maintained in terms of reference standards periodically calibrated by the National Bureau of Standards.

Stability: Capacitance change is less than 0.01% per year.

Temperature Coefficient of Capacitance: +35 ± 10 ppm per degree between 10° and 70°C.

Dissipation Factor: Less than 0.0003 at 1 kHz and 23°C (see curves). Measured dissipation factor at 1 kHz is stated in the certificate to an accuracy of ±0.00005.

Series Inductance: Typically 0.050 μH for 1409-F through -M, 0.055 μH for -R through -Y.

Series Resistance at 1 MHz: 0.02 ohm, except for 1409-Y, which is 0.03 ohm.

Frequency Characteristics: See curves. Series resistance varies as the square root of the frequency for frequencies above 100 kHz.

Approx Terminal Capacitance: From H terminal to case (G), 12 to 50 pF. From L terminal (outside foils of capacitor) to case, 300 to 1300 pF.

Leakage Resistance: 5000 ohm-farads or 100 GΩ, whichever is the lesser.

Max Voltage: 500 V pk up to 10 kHz.

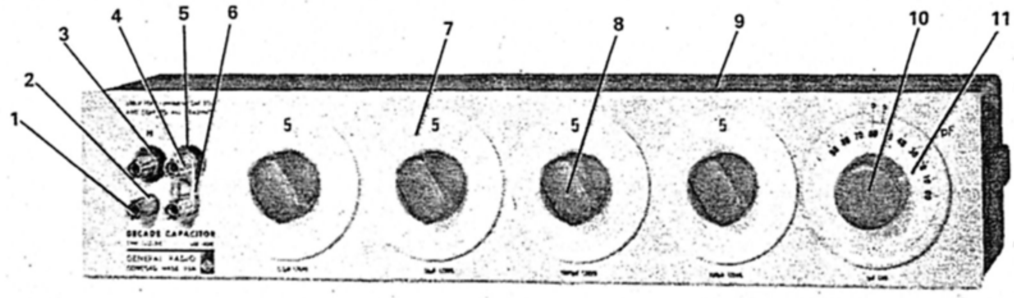
Dimensions (width x height x depth): 1409-Y, 3¼ x 5⅝ x 2¹¹⁄₁₆ in. (85 x 145 x 70 mm); 1409-X, 3¼ x 4 x 2¹¹⁄₁₆ in. (85 x 105 x 70 mm); others, 3¼ x 4 x 2 in. (85 x 105 x 50 mm).

Weight: Net, 1¼ lb (0.6 kg); shipping, 4 lb (1.9 kg). Add approx ½ lb (0.2 kg) for 1409-X, and approx 1 lb (2.2 kg) for 1409-Y.

Catalog Number	Type	Nominal Capacitance μF
1409-9706	1409-F	0.001
1409-9707	1409-G	0.002
1409-9711	1409-K	0.005
1409-9712	1409-L	0.01
1409-9713	1409-M	0.02
1409-9718	1409-R	0.05
1409-9720	1409-T	0.1
1409-9721	1409-U	0.2
1409-9724	1409-X	0.5
1409-9725	1409-Y	1.0

GenRad

GR 1412-BC Decade Capacitor



MECHANICAL PARTS LIST

Fig Ref	Qnt	Description	GR Part No.
1	2	Binding post asm.	0938-3022
2	2	Spacer	7800-0600
3	1	Binding post asm.,	0938-3070
4	1	Binding post asm.,	0938-3058
5	3	Bushing	0938-7130
	1	Bushing	0938-7131
6	1	Shorting Links	5080-4800
7	4	Dial asm.,	5120-2120
8	4	Knob asm.,	5500-5420

Fig Ref	Qnt	Description	GR Part No.
		Knob	5500-5404
		Retainer	5220-5401
9	1	Cabinet asm	1412-1040
10	1	Knob asm., 1 pF Div.	5520-5420
		Includes:	
		Knob	5520-5400
		Retainer	5520-5401
11	1	Dial asm., 1 pF Div.	5120-2121
	4	Foot, rubber	5260-1200

ELECTRICAL PARTS LIST

Ref Des	Description	GR Part No.
CAPACITORS		
C1	Variable	0368-4100
C2	Poly, 99 pF ±0.6% 500 V	4872-1050
C3 and		
C4	Poly, 198.8 pF ±0.6% 500 V	4872-1051
C5	Poly, 498 pF ±0.6% 500 V	4872-1052
C6	Poly, 997 pF +.05%-.45% 500 V	4872-1053
C7 and		
C8	Poly, 1995 pF +.05%-.45% 500 V	4872-1080
C9	Poly, 4987 pF +.05%-.35% 500 V	4872-1081
C10	Poly, .01 μF +.05%-.35% 500 V	4872-1082
C11 and		
C12	Poly, .02 μF +.05%-.35% 500 V	4872-1060
C13	Poly, .05 μF +.05%-.35%, 500 V	4872-1070
C14	Poly, 0.1 μF +.05%-.35% 500 V	4872-1171
C15 and		
C16	Poly, 0.2 μF +.05%-.35% 500 V	4872-1179

Ref Des	Description	GR Part No.
C17	Poly, 0.50 μF + .05% - .35% 500 V	1412-1100
C18	Cer., 2.2 ±0.25 pF or Cer., 4.7 ±0.5 pF	4400-2450 4400-2700*
CONNECTORS		
J1	Binding post	0938-3070
J2	Binding post	0938-3022
J3	Binding post	0938-3058
J4	Binding post	0938-3022
SWITCHES		
S1	Switch	7890-4140
S2 thru		
S4	Switch	7890-4150

*Selected by General Radio Company to produce a zero reading of 48-50 pF in individual instruments.

SPECIFICATIONS

Capacitance: 50 pF to 1.11115 μF in steps of 100 pF with a 0- to 100-pF variable air capacitor providing continuous adjustment with divisions of 1 pF. Capacitances for 2- and 3-terminal connections differ by about 1 pF (C_{HG} in the drawing). C_{LG} is approx 125 pF.

Min Capacitance: 50 pF with all controls set at zero.

Dielectric: Polystyrene for decade steps.

Accuracy: ±(0.5% + 5 pF) at 1 kHz for total capacitance including 50-pF minimum for the 3-terminal connection.

Temperature Coefficient: −140 ppm/°C (nominal).

Frequency Characteristics: Dc Cap/1-kHz Cap <1.001. At higher frequencies the increase is approx $\Delta C/C = (f/f_r)^2$. The resonant frequency, f_r, varies from over 400 kHz for a capacitance of 1 μF to about 27 MHz for a capacitance of 150 pF when connections are made to the front terminals. f_r is about 300 kHz and 70 MHz for rear connections and the same capacitances.

Max Operating Temperature: 65°C.

Dielectric Absorption (Voltage Recovery): 0.1% max.

Dissipation Factor: 150 to 1000 pF, 0.001, max, at 1 kHz, at 23°C and relative humidity <50%; over 1000 pF, 0.0002, max, at 1 kHz.

Insulation Resistance: 10^{12} ohms, min.

Max Voltage: 500 V peak, up to 35 kHz.

Terminals: Four 938 Binding Posts with grounding link are provided on the panel. Two of the binding posts are connected to the case and located for convenient use with patch cords in 3-terminal applications. Access is also provided to rear terminals for relay-rack applications.

Mechanical: Lab-bench cabinet; brackets provided for rack mounting. DIMENSIONS (wxhxd): 17.25x3.5x6 in. (439x89x153 mm). WEIGHT: 8.5 lb (3.9 kg) net, 10 lb (4.6 kg) shipping.

Description	Catalog Number
1412-BC Decade Capacitor	**1412-9410**

1 INTRODUCTION

1.1 PURPOSE.

The Type 1412-BC Decade Capacitor is a high-quality, wide-range instrument ideally suited to decade capacitor applications ranging from experimental circuits on a laboratory bench to permanent installations in a relay rack.

Designed for versatility, this Decade Capacitor features fine adjustment over a wide range of capacitance, high resolution, and provision for two- or three-terminal connections on either the front panel or the rear of the instrument. The decade box has polystyrene capacitors with excellent dc and ac characteristics. Its low inductance permits use up into the supersonic frequency range with relatively little change in effective capacitance.

1.2 DESCRIPTION.

An air capacitor makes available a continuously variable range of 0 to 100 pF. In the four decades, polystyrene capacitors are used for steps of 100 pF, 1000 pF, 0.01 µF, and 0.1 µF. The capacitors are housed in a double-shielded inner box and case as shown in Figure 1.

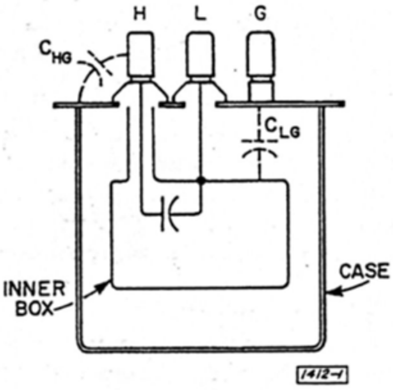


Figure 1. The double shielding used in the Type 1412-BC Decade Capacitor keeps C_{HG} very small. This capacitance is the difference between the three-terminal and two-terminal capacitance of the box; C_{LG} is approximately 125 pF.

Ceramic-insulated switches, with solid-silver-alloy contacts, select parallel combinations of capacitors having values in the ratio of 1, 2, 2, and 5. The polystyrene capacitors are of extended foil construction for minimum inductance and low series resistance. This dielectric material is used for stability of capacitance, low dielectric losses, and high insulation resistance.

Mounting hardware is provided for installing the instrument in a relay rack.

2 OPERATING PROCEDURE

2.1 MOUNTING.

The Type 1412-BC Decade Capacitor is housed in a cabinet for convenient bench use. Additional mounting hardware is also supplied for installation in a relay rack. To install the instrument in a relay rack:

a. Remove the black nylon buttons from the holes at the side panels of the instrument. These buttons are press fitted and are easily removed with a small screwdriver.

b. Install the 3 1/2 by 7/8 inch adaptor-panel assemblies (A) on each side of the instrument, using the 3/8-inch locking screws (B) supplied. The holes in the side-panel of the instrument are tapped with a 10-32 thread to receive these screws.

c. Mount the assembly in a standard 19-inch relay-rack cabinet, using the 5/8-inch No. 10-32 screws (C) and nylon washers (D) provided.

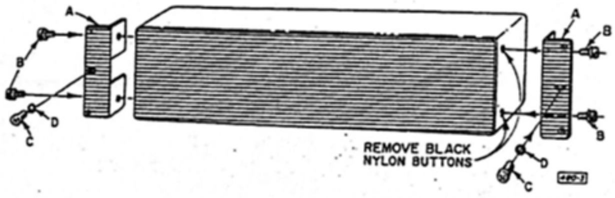
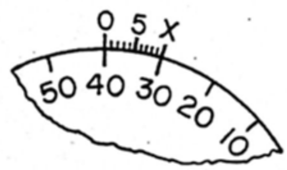


Figure 2. Relay-rack installation of Type 1412-BC.

2.2 READOUT.

The four decades of polystyrene capacitors have clear, easy-to-read dials with numbered steps from 0 to X (X=10). The dial provided with the continuously adjustable air capacitor has ten 10-pF divisions for a total range of 0 to 100 pF, plus additional readout to 1 pF per graduation. The dial is easy to read, simply add the number of graduations (counting from 0) on the fixed vernier scale to the corresponding numbered division on the dial. Sample settings are illustrated in the following examples:

Read:
30 + 3 = 33 pF



Read:
30 + X(10) = 40 pF
or
40 + 0 = 40 pF

2.3 FRONT CONNECTIONS.

The four terminals on the front panel of the Type 1412-BC are arranged in a square with standard 3/4-inch spacing for either two-terminal or three-terminal connection. With this arrangement, a wide variety of connectors, in various combinations, can be used. Typical examples are shown in Figures 3 through 6.

For general use, the two-terminal and three-terminal decade capacitances differ only by the small capacitance (C_{HG}) of the binding post H to the case. It is particularly desirable that this capacitance be as small as possible when using low values of decade capacitance with the Type 1654 Impedance Comparator and with many special bridges.

3.3 FREQUENCY CHARACTERISTICS.

Variations of capacitance with changes in frequency are principally a function of the dielectric material below 1 kHz and a function of the amount of series inductance above 1 kHz. Polystyrene dielectric ensures negligible variations of capacitance below 1 kHz and extended foil construction provides a minimum value of inductance above 1 kHz.

Most of the inductance in the Decade Capacitor is in the wiring. This inductance is low enough to keep the increase in effective capacitance to a reasonably low value over the frequency range in which the instrument is likely to be used. When the operating frequency (f) is well below the resonant frequency (f_r), the approximate increase in effective capacitance (ΔC) over the zero-frequency capacitance (C_o) is given by the expression:

$$\frac{\Delta C}{C_o} \approx \left(\frac{f}{f_r}\right)^2$$

Typical values of the resonant frequency are given in the table below.

Decade Capacitance	Resonant Frequency	
	Front Terminals	Rear Terminals
1.11115 µF	430 kHz	310 kHz
1.0 µF	440 kHz	320 kHz
0.1 µF	1.25 MHz	1.2 MHz
0.01 µF	3.5 MHz	4.3 MHz
1050 pF	10 MHz	17 MHz
150 pF	27 MHz	70 MHz

At frequencies up to 30 kHz, the effective capacitance at any setting will be less than 1% higher than the value of capacitance at 1 kHz. At most settings, the error will be much smaller.

3.4 DISSIPATION FACTOR.

The dissipation factor of the polystyrene dielectric is quite low and relatively constant over the frequency range ordinarily encountered in most applications. Under certain operating conditions, minor increases can be expected in the dissipation factor of the Type 1412-BC Decade Capacitor.

At the lower capacitance settings, the dissipation factor of the decade box is increased by losses in the switch insulation and other materials outside of the capacitors. These losses tend to increase as the frequency is lowered.

At higher capacitance settings, the dissipation factor is increased by the series resistance of the wiring. This effect will become greater as the frequency is increased.

4 SERVICE AND MAINTENANCE

4.1 WARRANTY.

Our warranty attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. Please write or phone the nearest GR service facility, giving full information of the trouble and of steps taken to remedy it. Describe the instrument by type, serial, and ID numbers. (Refer to front and rear panels.)

4.2 SERVICE.

Before returning an instrument to General Radio for service, please ask our nearest office for a "Returned Material" number. Use of this number in correspondence and on a tag tied to the instrument will ensure proper handling and identification. After the initial warranty period, please avoid unnecessary delay by indicating how payment will be made, i.e., send a purchase-order number or (for transportation charges) request " "C.O.D."

For return shipment, please use packaging that is adequate to protect the instrument from damage, i.e., equivalent to the original packaging. Advice may be obtained from any GR office.

WARRANTY

We warrant that this product is free from defects in material and workmanship and, when properly used, will perform in accordance with applicable GenRad specifications. If within one year after original shipment it is found not to meet this standard, it will be repaired or, at the option of GenRad, replaced at no charge when returned to a GenRad service facility. Changes in the product not approved by GenRad shall void this warranty. GenRad shall not be liable for any indirect, special, or consequential damages, even if notice has been given of the possibility of such damages.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

GenRad policy is to maintain product repair capability for a period of ten years after original shipment and to make this capability available at the then prevailing schedule of charges.

Form 1412-0100-D
December 1975
ID 2871

300 BAKER AVENUE, CONCORD, MASSACHUSETTS 01742

Printed in USA

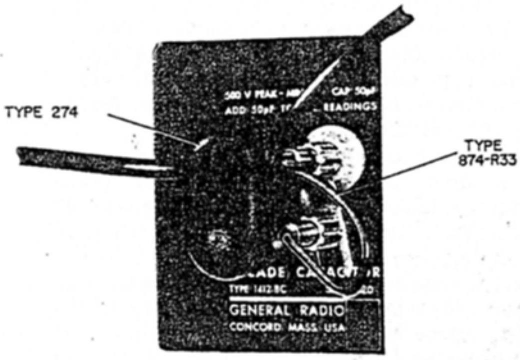


Figure 3. Front panel of Type 1412-BC showing three-terminal connection with both shields connected to the case.

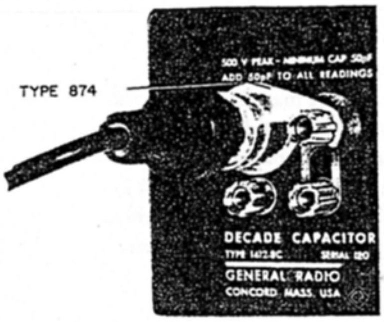


Figure 4. Type 1412-BC showing two-terminal (grounded) connection using Type 874

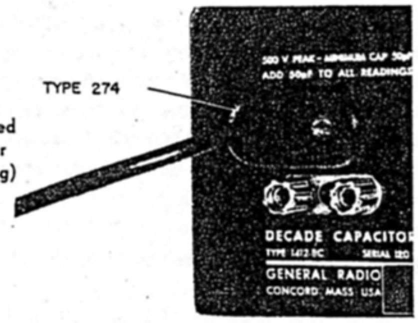


Figure 5. Type 274- Shielded Double Plug used for two-terminal (floating) connection on Type 1412-BC.

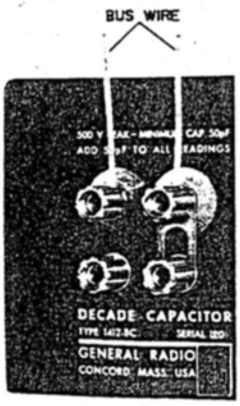


Figure 6. Type 1412-BC with two-terminal (grounded) connection using bus wire.

2.4 REAR CONNECTIONS.

To make connections at the rear of the instrument (see Figure 7):

a. Remove the two 6-32 screws (G) and the small rectangular plate from the rear panel. Thread the two screws (G) back into the panel after removing the plate.

b. Thread the spacer and then one of the 1/4 inch No. 6-32 screws (spacer and screws supplied) on the recessed terminal H.

c. Thread the remaining 1/4-inch No. 6-32 screw into terminal L.

NOTE

Lug terminals are supplied and can be installed with the terminal screws as desired.

Connections can now be made to terminals L, H, and G.

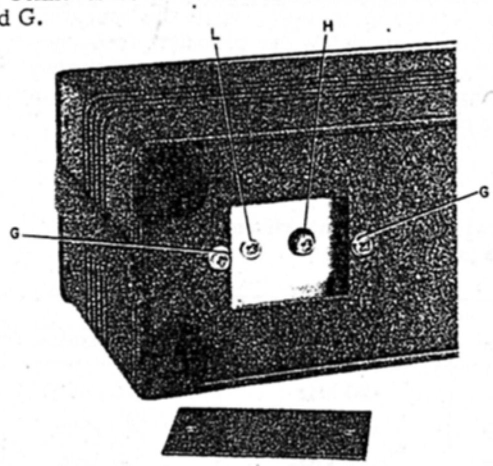


Figure 7. Rear panel view of Type 1412-BC showing terminals for rear connections.

3 PRINCIPLES OF OPERATION

3.1 GENERAL.

The following paragraphs briefly describe some of the more important principles of operation applicable to the Type 1412-BC Decade Capacitor. For a detailed discussion of the characteristics of standard capacitors, refer to the General Radio Catalog.

3.2 CONNECTIONS.

The Type 1412-BC is designed for either two-terminal or three-terminal connection. (See Figure 1 for a diagram of the shielding elements and connection terminals.) Because the inner box is connected to terminal L, the high side (H) of the decade capacitance is almost completely shielded from the outer case.

Type 1423-A PRECISION DECADE CAPACITOR

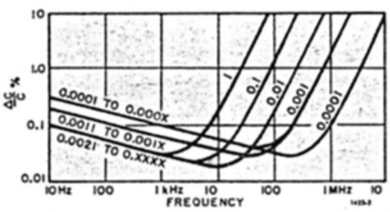
- 100 pF to 1.111 μF
- ±0.05 % accuracy
- two- or three-terminal connection

This capacitor is a versatile tool for calibration laboratories and production-line testing. With it a bridge can be standardized to an accuracy exceeded only by that of the highest quality, individually certified laboratory standards such as the GR 1404 Reference Standard Capacitors. Used with a limit bridge, such as the GR 1605-A Impedance Comparator, the 1423 facilitates fast and accurate production-line measurements of arbitrary capacitance values with minimum setup time.

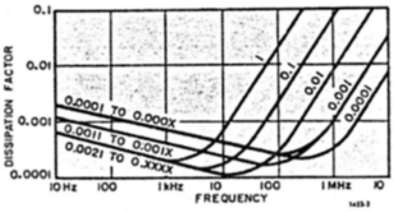
Any value of capacitance from 100 pF to 1.111 μF, in steps of 100 pF, can be set on the four decades and will be known to an accuracy of 0.05%. The terminal capacitance values are set precisely to the nominal value and can be readjusted later at calibration intervals, if necessary, without disturbance of the main capacitors.

The 1423 consists of four decades of high-quality silvered-mica capacitors similar to those used in the GR 1409 Standard Capacitors. The capacitors and associated switches are mounted in an insulated metal compartment, which in turn is mounted in a complete metal cabinet. This double-shielded construction ensures that capacitance at the terminals is the same for either the three-terminal or the two-terminal method of connection (except for a constant difference of about one picofarad). This external capacitance can be included in the two-terminal calibration by the adjustment of a single trimmer.

— See **GR Experimenter** for June 1961.



(Left) Change in capacitance as a function of frequency. These changes are referred to the values that the capacitors would have if there were neither interfacial polarization nor series inductance. The 1-kHz value on the plot should be used as a basis of reference in estimating frequency errors. (Right) Dissipation factor as a function of frequency.



specifications

Nominal Values: 100 pF to 1.111 μF in steps of 100 pF.

Accuracy: ±(0.05% + 0.05pF) at 1 kHz, calibrated in the three-terminal connection. Two-terminal connection (capacitor inserted into Type 777-Q3 Adaptor) adds about 1.3 pF reading.

Stability: ±(0.01% + 0.05pF) per year.

Certificate: A certificate is supplied certifying that each component capacitor was adjusted by comparison, to a precision better than ±0.01%, with working standards whose absolute values are known to an accuracy typically ±0.01%, determined and maintained in terms of reference standards periodically calibrated by the National Bureau of Standards.

Frequency: See curves for typical variation of capacitance and dissipation factor with frequency.

Dissipation Factor: Not greater than 0.001, 0.0005, and 0.0003 for capacitances of 100 to 1000 pF, 1100 to 2000 pF, and 2100 pF to 1.1110 μF, respectively.

Temperature Coefficient of Capacitance: Approx +20 ppm per degree between 10° and 50°C.

Insulation Resistance: $>5 \times 10^{10}$ Ω to 0.1 μF and $>5 \times 10^{9}$ Ω from 0.1 μF to 1.111 μF.

Maximum Voltage: 500 V peak, up to 10 kHz.

Accessories Supplied: Two Type 777-Q3 Adaptors.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench, 19 x 7¼ x 10½ in. (485 x 185 x 270 mm); rack, 19 x 7 x 8½ in. (485 x 180 x 220 mm).

Weight (both models): Net, 26 lb (12.0 kg); shipping, 39 lb (18 kg).

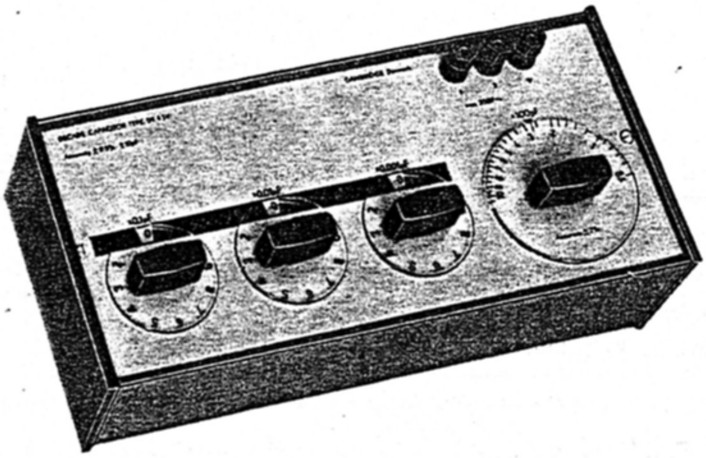
Catalog Number	Description
	Precision Decade Capacitor
1423-9801	1423-A, Bench Model
1423-9811	1423-A, Rack Model

DANBRIDGE DENMARK

research production education

DECADE CAPACITORS TYPE DK

- IN-LINE READING
- LOW LOSSES
- GOOD ACCURACY
- WIDE RANGE OF VALUES
- SMALL DIMENSIONS
- HIGH STABILITY



These decade condensers are due to their relative cheapness, low losses and small dimensions very valuable for general laboratory work and educational purposes. They find uses in every laboratory as tuned circuit elements, bridge impedances and filter elements and are very useful components in a number of other applications in service and laboratory work.

SPECIFICATION

The decade condensers are manufactured in various types with decades from 10×0.001 μF to 10×1 μF. The specifications for the various capacitors employed are as follows:

POLYSTYRENE CAPACITORS

These are used for all S type decades, except for the 10×1 μF decade in type DK4S, and are also used for the 10×0.001 μF and 10×0.01 μF decades in types with suffix A.
The capacitors used in S type boxes are stabilised by a special process ensuring a good stability over long periods (about 0.1% for capacitors of 0.01 μF and larger) and are mounted in totally sealed cans. Adjustment accuracy is ½%. Power factor $2\text{–}5\times10^{-4}$. Maximum alternating voltage 200. Temperature coefficient about -130×10^{-6}.
The capacitors used in A type boxes are not stabilised and accordingly their stability is somewhat inferior to that of the S types. Accuracy 2½%. Power factor $2\text{–}5\times10^{-4}$. Maximum alternating voltage 200. Temperature coefficient about -130×10^{-6}.

POLYCARBONATE CAPACITORS

Are used for the 10×0.1 μF decade in types with suffix A and for the 10×1 μF decade in type DK4S & DK4A. They are mounted in hermetically sealed cans and feature a high stability. Adjusted to 1% or 2½% accuracy. Temperature coefficient about $+200\times10^{-6}$. Power factor 5×10^{-3}. Maximum alternating voltage 200.

AIR CAPACITORS

Types with suffix V are made continuously variable by addition of a small type air capacitor with a dial calibrated directly in pF. Calibration accuracy is 2% or 5 pF. Maximum alternating voltage 200.

TERMINALS

Two insulated terminals are provided, with a separate earth terminal on the metal cabinet.
The terminal next to the earth terminal has the greatest capacitance to the shield and should be used as the "low" potential terminal if required connected to the earth terminal.
The terminals are screw terminals with hole for 4 mm banana plugs. Terminal spacing ¾″ (19 mm).

SWITCHES

Each decade is made up of 4 capacitors with values 1–2–2 and 5 units. These are connected as required by a 4 section wafer switch with high quality insulation and silver contacts.

MOUNTING

Cabinet in blue plasticcoated aluminium with end castings in blue-grey enamel. Top panel finished in light-grey enamel.

MEASURING FREQUENCY

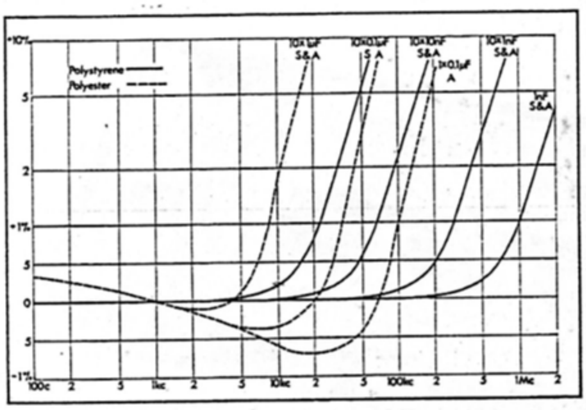
All data are measured at 1 kHz.

FREQUENCY CHARACTERISTICS

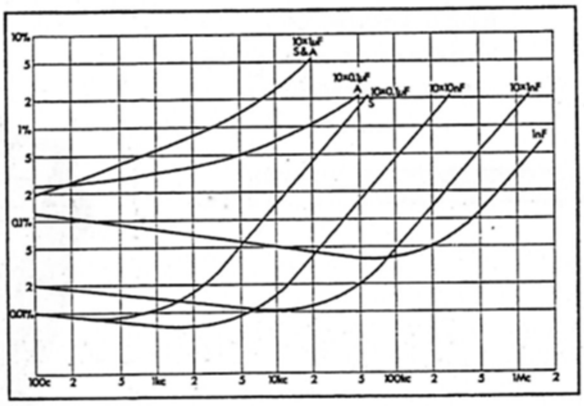
See curves below.

ZERO CAPACITANCE

Direct capacitance between terminals: For types DK4A–DK4S 10–20 pF. Capacitance between terminals with earth terminal and nearest terminal interconnected: For types DK4A–DK4S 25–35 pF. The above values should be added to the dial readings for accurate measurements.
For types with suffix V no correction is required when used with the earth terminal connected to the nearest terminal. The direct capacitance is about 15 pF less than the indicated value.



Change in capacitance with frequency for DK decade capacitors. Typical values.



Dissipation factor vs. frequency for DK decade capacitors. Typical values.

Type	Decade Value µF					Accuracy	Maximum AC voltage	Total Dimensions	Weight kilos
	10×0.001	10×0.01	10×0.1	10×1					
DK 4 A	Polystyrene		Polycarbonate			2½%	200	115×150×325 mm	2.6
DK 4 S	Polystyrene			Poly-carbonate		½% + 5 pF 10 × 1 µF 1%	200	115×150×325 mm	2.8
DK 4 AV	Polystyrene		Poly-carbonate	Calibrated variable air capacitor 50-1050 pF		2½% + 10 pF	200	115×150×325 mm	2.2
DK 4 SV	Polystyrene			Calibrated variable air capacitor 50-1050 pF		½% + 10 pF	200	115×150×325 mm	2.4

WE RESERVE THE RIGHT TO DEVIATE FROM THIS SPECIFICATION

DANBRIDGE DENMARK

A/S DANBRIDGE
47, BRIGADEVEJ . COPENHAGEN S . DENMARK
TELEPHONE: ASTA *1575
CABLES: DANBRIDGE-COPENHAGEN
TELEX: 2775

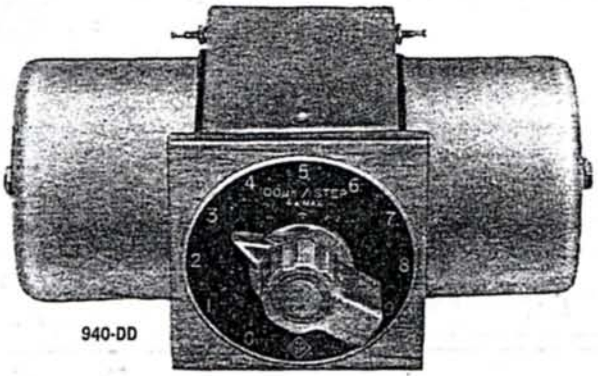
Rappresentanza Generale per l'Italia
Ing. UGO de LORENZO & C. s.r.l.
MILANO - Via Bellarmino, 29 - Tel. 843.95.08 - 843.99.97

PRINTED IN DENMARK

LEAFLET NO. 1012 B

AXELHOLM A/S.

Type 940 DECADE-INDUCTOR UNIT



Each 940 Decade-Inductor Unit is an assembly of four inductors (relative values, 1, 2, 2, 5) wound on molybdenum-permalloy dust cores, which are combined by switching to give the eleven successive values from 0 to 10. The decade switch has high-quality ceramic stator-and-rotor members and well-defined ball-and-socket detents. All contacts are made of a silver alloy and have a positive wiping action.

specifications

Accuracy: Each unit is adjusted so that its inductance at zero frequency and initial permeability will be the nominal value within the accuracy tolerance given in the following table:

Unit	940-DD	940-E	940-F	940-G	940-H
Inductance per step	100 μH	1 mH	10 mH	100 mH	1 H
Accuracy	±2%	±2%	±1%	±0.6%	±0.6%

Under our standard warranty, this accuracy is guaranteed for 2 years if the inductor has not been damaged.

Frequency Characteristics: For any specific operating frequency, Figure 2 shows the percentage increase in effective series inductance (above the value when f = 0), which is encountered with the extreme settings of each of the five decade-inductor units when the chassis is floating. Interpolation may be used for intermediate settings.

Change in Inductance with Current: Fractional change in initial inductance with ac current for each type of toroid is shown in the normal curves, Figure 1, in terms of the ratio of the operating current, I, to I_1, the current for 0.25% change, solid line (0.1%, broken line). For ratios below unity, inductance change is directly proportional to current. Values of I_1, listed below, are approximate and are based on the largest inductor in the circuit for each setting.

Incremental Inductance: Dc bias current I_b will reduce the initial inductance as shown in the incremental curves, Figure 1.

RMS I_1 (mA)

Switch Setting	0.1% Increase	0.25% Increase			
	940-DD	940-E	940-F	940-G	940-H
1	141	17	5.4	1.7	0.54
2, 3, 4	100	12	3.8	1.2	0.38
5, 6, 7, 8, 9, 10	63	8	2.4	0.8	0.24

Storage Factor Q: See Figure 3.

Dc Resistance: Approx 45 Ω per henry.

Temperature Coefficient: Approx −25 ppm per degree C between 16° and 32°C.

Max Safe Current: Approx 200 times the pertinent I_1 value (30 times for the 940-DD). Max current engraved on dial.

Terminals: Solder lugs. Circuit insulated from chassis.

Mounting: Hardware included, with dial plate and knob.

Dimensions (width x height x depth): 8 x 3½ x 4¼ in. (205 x 90 x 110 mm).

Weight: Net, 3½ lb (1.6 kg); shipping, 6 lb (2.8 kg).

Catalog Number	Description	Inductance Total	Inductance Steps	
	Decade Inductor			
0940-9810	**940-DD**	1 mH	100 μH	280.000
0940-9705	**940-E**	0.01 H	0.001 H	255.000
0940-9706	**940-F**	0.1 H	0.01 H	185.000
0940-9707	**940-G**	1 H	0.1 H	
0940-9708	**940-H**	10 H	1 H	

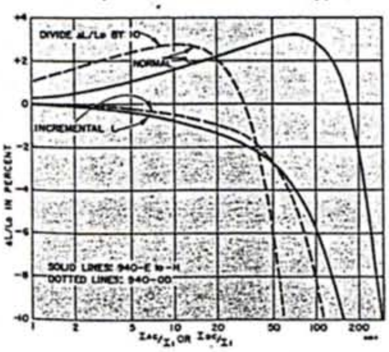


Figure 1. Percentage change in normal and incremental inductance with ac and bias current. Incremental curve is limited to an ac excitation less than I_1.

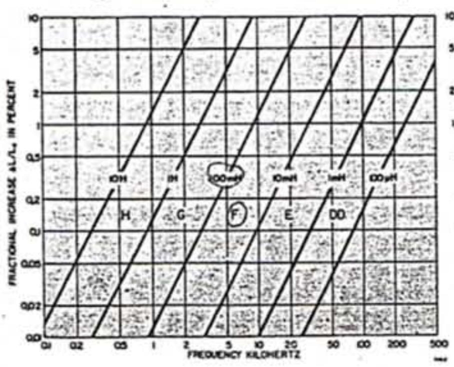


Figure 2. Change in effective inductance with frequency for the 940 Decade-Inductor Units.

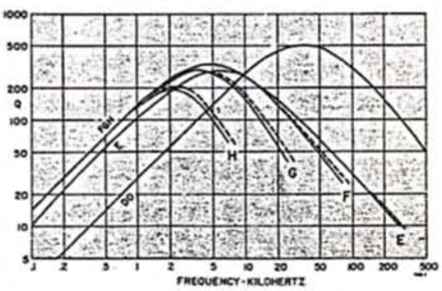
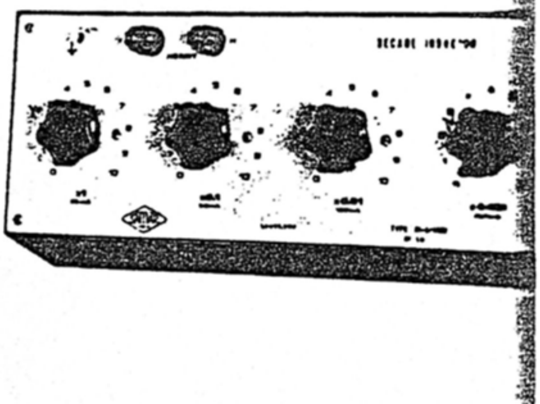


Figure 3. Variation of Q for the maximum inductance of each 940 Decade-Inductor Unit at low excitation levels. Dashed curves correspond to use with chassis floating.

CASSETTE DI INDUTTANZA A COMMUTATORE

Tipi CI-E/DC e CI-B/DC

Cassette di induttanza a commutatore realizzate per usi generali nelle scuole e nei laboratori.



Tipo CI-E/4DC2 • C

DATI COSTRUTTIVI

Bobine di rame avvolte su supporti ceramici.
Due morsetti d'attacco e morsetto di massa.
Precisione: a 1.000 Hz, riferita ai morsetti.

FINITURA

Cassetta metallica a leggio, verniciata in testa di moro goffrato.
Il pannello è verniciato a fuoco in color sabbia vetrificata e porta i morsetti, tutti gli organi di comando e le indicazioni a due colori.

DATI TECNICI

Tipo	Sezioni H	Induttanza totale H	Precisione %	Correnti massime decade H	Correnti massime mA	Dimensioni mm	Peso kg
TIPO CI-E/DC							
CI-E/5DC1	10 × (0,0001 + 0,001 + 0,01 + 0,1 + 1)	11,111				450 × 135 × 140	3,1
CI-E/4DC1 CI-E/4DC2	10 × (0,0001 + 0,001 + 0,01 + 0,1) 10 × (0,001 + 0,01 + 0,1 + 1)	1,111 11,11				365 × 135 × 140	2,5
CI-E/3DC1 CI-E/3DC2 CI-E/3DC3	10 × (0,0001 + 0,001 + 0,01) 10 × (0,001 + 0,01 + 0,1) 10 × (0,01 + 0,1 + 1)	0,111 1,11 11,1		0,0001 0,001	500 200	280 × 135 × 140	1,9
CI-E/2DC1 CI-E/2DC2 CI-E/2DC3 CI-E/2DC4	10 × (0,0001 + 0,001) 10 × (0,001 + 0,01) 10 × (0,01 + 0,1) 10 × (0,1 + 1)	0,011 0,11 1,1 11	± 1	0,01 0,1 1	100 50 25	195 × 135 × 140	1,3
CI-E/1DC1 CI-E/1DC2 CI-E/1DC3 CI-E/1DC4 CI-E/1DC5	10 × 0,0001 10 × 0,001 10 × 0,01 10 × 0,1 10 × 1	0,001 0,01 0,1 1,0 10				120 × 115 × 140	0,8
TIPO CI-B/DC							
CI-B/5DC1	10 × (0,0001 + 0,001 + 0,01 + 0,1 + 1)	11,111				450 × 135 × 140	3,1
CI-B/4DC1 CI-B/4DC2	10 × (0,0001 + 0,001 + 0,01 + 0,1) 10 × (0,001 + 0,01 + 0,1 + 1)	1,111 11,11				365 × 135 × 140	2,5
CI-B/3DC1 CI-B/3DC2 CI-B/3DC3	10 × (0,0001 + 0,001 + 0,01) 10 × (0,001 + 0,01 + 0,1) 10 × (0,01 + 0,1 + 1)	0,111 1,11 11,1		0,0001 0,001	500 200	280 × 135 × 140	1,9
CI-B/2DC1 CI-B/2DC2 CI-B/2DC3 CI-B/2DC4	10 × (0,0001 + 0,001) 10 × (0,001 + 0,01) 10 × (0,01 + 0,1) 10 × (0,1 + 1)	0,011 0,11 1,1 11	± 5	0,01 0,1 1	100 50 25	195 × 135 × 140	1,3
CI-B/1DC1 CI-B/1DC2 CI-B/1DC3 CI-B/1DC4 CI-B/1DC5	10 × 0,0001 10 × 0,001 10 × 0,01 10 × 0,1 10 × 1	0,001 0,01 0,1 1,0 10				120 × 115 × 140	0,8

SINE / SQUARE OSCILLATOR
209A

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This section contains general information about the -hp- Model 209A Sine/ Square Oscillator. Throughout this manual the instrument will be referred to as the Model 209A.

1-3. SPECIFICATIONS.

1-4. Table 1-1 lists the specifications for the Model 209A.

1-5. DESCRIPTION.

1-6. The Model 209A is a versatile signal source with independent sine wave and square wave outputs at frequencies from 4 Hz to 2 MHz. The square wave amplitude is variable to a maximum of 20 volts peak-to-peak into open circuit. The sine wave amplitude is variable to a maximum of 10 volts rms into open circuit from a constant 600 ohm source. When working into a 600 ohm load, the maximum output level is 5 volts rms.

1-7. Balanced output can be obtained by disconnecting the grounding strap at the rear of the instrument. This isolates the chassis from the cabinet and line ground. The sine wave output will balance to greater than 40 dB, at frequencies below 20 kHz, with the chassis isolated.

1-8. The Model 209A can be synchronized with an external source. With a 5 volt rms sync input, the external source may vary as much as +/-7% in frequency and the Model 209A will remain synchronized.

1-9. A sync output of 1.7 volts rms is also available at the same front panel terminal used to accept an external sync source.

1-10. INSTRUMENT/MANUAL IDENTIFICATION.

1-11. Hewlett-Packard uses a two-section serial number. The first section (prefix) identifies a series of instruments. The last section (suffix) identifies a particular instrument within the series. If a letter is included with the serial number, it identifies the country in which the instrument was manufactured. If the serial prefix of your instrument differs from the one on the title page of this manual, a change sheet will be supplied to make this manual compatable with newer instruments or the backdating information in Appendix C will adapt this manual to earlier instruments. All correspondence with Hewlett-Packard should include the complete serial number.

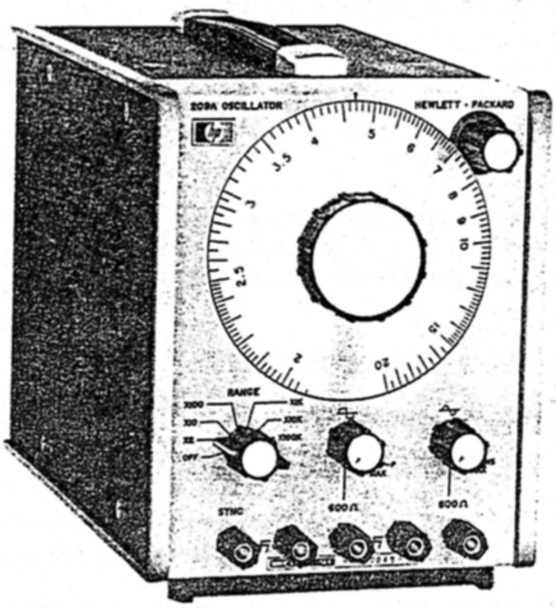
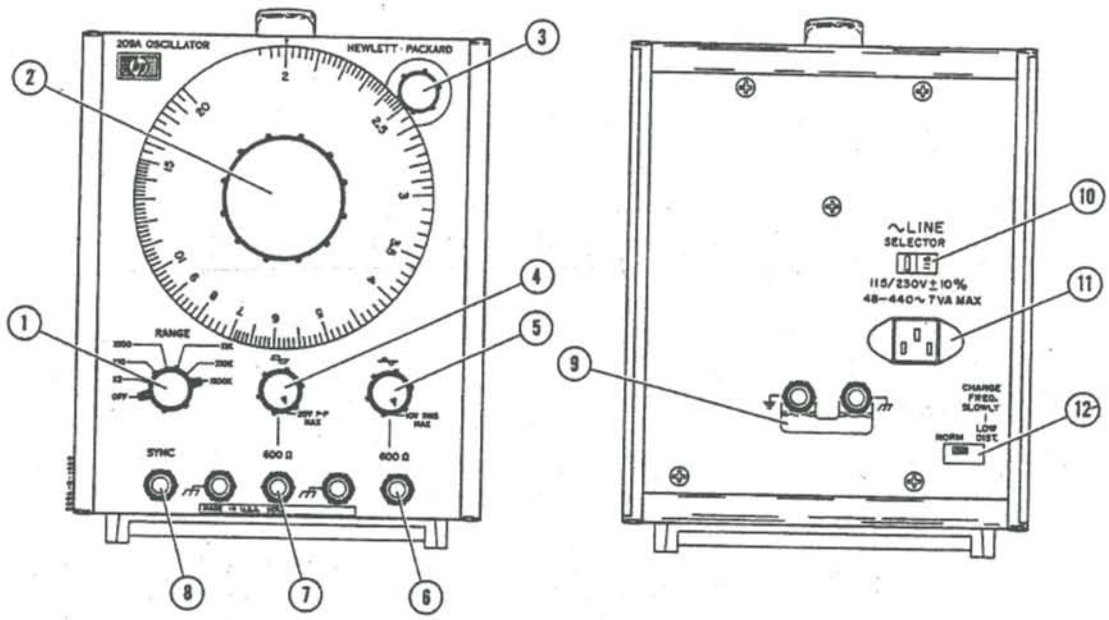


Figure 1-1. Model 209A Sine/Square Oscillator



(1) RANGE Switch: Selects frequency range or OFF position.

(2) Frequency Dial: Selects frequency within desired range. Dial setting multiplied by RANGE switch position indicates output frequency.

(3) Frequency Vernier: Provides fine tuning of frequency dial.

(4) Square Wave Amplitude Control: Varies Square Wave output level to 20 volts peak-to-peak, open circuit.

(5) Sine Wave Amplitude Control: Varies Sine Wave output level over a 20 dB range to 10 volts rms, open circuit (5 volts rms into 600 ohms).

(6) Sine Wave Output Terminal: 600 ohm sine wave output at a frequency and amplitude determined by control settings.

(7) Square Wave Output Terminal: 600 ohm square wave output at a frequency and amplitude determined by control settings.

(8) SYNC Terminal: (1) Input terminal for an external sync signal. (2) Output terminal for 1.7 volt rms sine wave sync signal.

(9) Ground Strap: Connects the floating circuit ground to power ground.

(10) Voltage Selector Switch: Selects line voltage of 115 volts or 230 volts AC.

(11) AC Power Receptacle: Mates with power cord supplied with this instrument for line voltage connection.

(12) NORM/LOW DIST. Switch: Selects normal or low distortion below 100 Hz.

Figure 3-1. Description of Controls and Connectors

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This section contains information as an aid to operating the Model 209A. Included are control and connector descriptions (Figure 3-1), and some special operating considerations.

3-3. TURN ON PROCEDURE.

3-4. To turn on the Model 209A, proceed as follows:

a. Set the two-position voltage selector switch on the rear panel to the value of available line voltage.

b. Connect the AC power cord to line voltage.

c. Switch the RANGE switch from OFF to the desired frequency range.

d. Select the desired frequency and voltage output with the frequency dial and amplitude controls respectively.

3-5. OPERATING CONSIDERATIONS.

3-6. FLOATING OUTPUT.

CAUTION

WHEN THE GROUND STRAP ON THE REAR PANEL IS CONNECTED, INPUT GROUND IS AT EARTH GROUND POTENTIAL.

3-7. When the ground strap on the rear of the Model 209A is disconnected, the chassis is isolated from power ground. The outputs may then be connected to any point with a dc potential of not more than +/-500 volts. If a dc voltage up to +/-500 volts is connected between the ground connectors on the rear panels, the oscillator output is dc offset by that amount.

3-8. BALANCE.

3-9. With the chassis isolated from the cabinet, the sine wave output will be balanced to greater than 40 dB at frequencies below 20 kHz. If the square wave output is being used simultaneously with the black terminal connected to ground, the sine wave output will no longer be balanced.

3-10. SYNCHRONIZATION.

3-11. The Model 209A is equipped with a SYNC terminal that provides a sync output signal or accepts a synchronizing input signal from an external source. The sync output signal is a 1.7 volt rms sine wave in phase with the oscillator output. The external sync signal can be any periodic waveform of sufficient amplitude to maintain sync. For an external sync signal with an amplitude of 5 volts rms, the oscillator will remain synchronized at frequencies of +/-7% of the set frequency.

3-12. The Model 209A can be synchronized to any significant harmonic of an external signal. However, if a harmonic or non-sinusoidal waveform is used to synchronize the Model 209A, some portion of the external sync signal will be on the output. This small signal will appear as distortion. The amount of this apparent distortion will be directly proportional to the amplitude of the sync signal. For a non-sinusoidal sync input of 2 volts peak-to-peak, the distortion will be down about -45 dB for frequencies which are normally down -60 dB.

3-13. LOW DISTORTION.

3-14. At frequencies below 100 Hz, distortion can be reduced by switching the NORM/LOW DIST switch on the rear panel to LOW DIST. In the LOW DIST mode the Model 209A will have a longer settling time when changing frequencies. To avoid this, set the desired frequency before switching to LOW DIST.

Table 1-1. Specifications

RANGES

Frequency: 4 Hz to 2 MHz in 6 ranges.

PERFORMANCE RATINGS

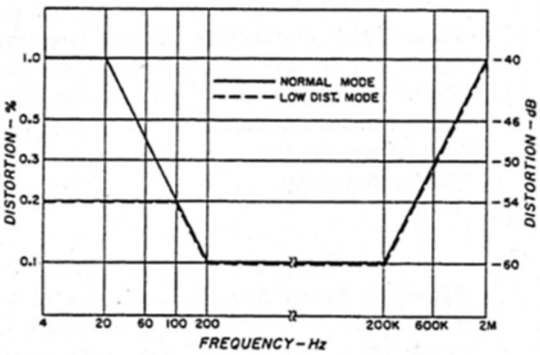
Dial Accuracy: +/-3% of frequency setting.

Flatness: At maximum output into 600 ohm load. 1 kHz reference.

Low Distortion Mode	+/-1%	+/-0.5%	+/-1%	+/-5%
Normal Mode	+5% -1%	+/-0.5%	+/-1%	+/-5%

(Hz) 4 100 300k 1M 2M

Distortion:



Hum and Noise: less than 0.01% of output.

OUTPUT CHARACTERISTICS

SINE WAVE

Output Voltage: 5 V rms (40 mW) into 600 ohms; 10 V open circuit. Output can be floated up to +/-500 V peak between output and chassis ground.

Output Impedance: 600 ohms.

Output Control: 20 dB range continuously adjustable.

Output Balance: greater than 40 dB below 20 kHz.

SQUARE WAVE

Output Voltage: 20 V p-p open circuit symmetrical about 0 V. Output can be floated up to +/-500 V peak between output and chassis ground.

Rise and Fall Time: less than 50 ns.

Symmetry: +/-5%

Output Impedance: 600 to 900 ohms depending upon setting of output control.

EXTERNAL SYNCHRONIZATION

Sync Impedance: 10 kilohm.

Sync Output: Sine wave in phase with output; amplitude working into 1 megohm shunted by 100 pF is greater than 1.7 V rms from 4 Hz to 50 kHz, greater than .1 V from 50 kHz to 2 MHz.

Sync Input: Oscillator can be synchronized to external signal. For 5 V rms input, sync frequency can be as much as +/-7% away from set frequency (sync range). Sync range is a linear function of sync voltage.

GENERAL

Operating Temperature: Instrument will operate within specifications from 0% C to 55% C.

Storage Temperature: -40% C to +75% C

Power: AC-Line 115V or 230V +/-10%, 48 Hz to 440 Hz, less than 7 W.

Dimensions:
Refer to Figure 2-1, page 2-2.

Accessories Available: HP 11075A Instrument Case.

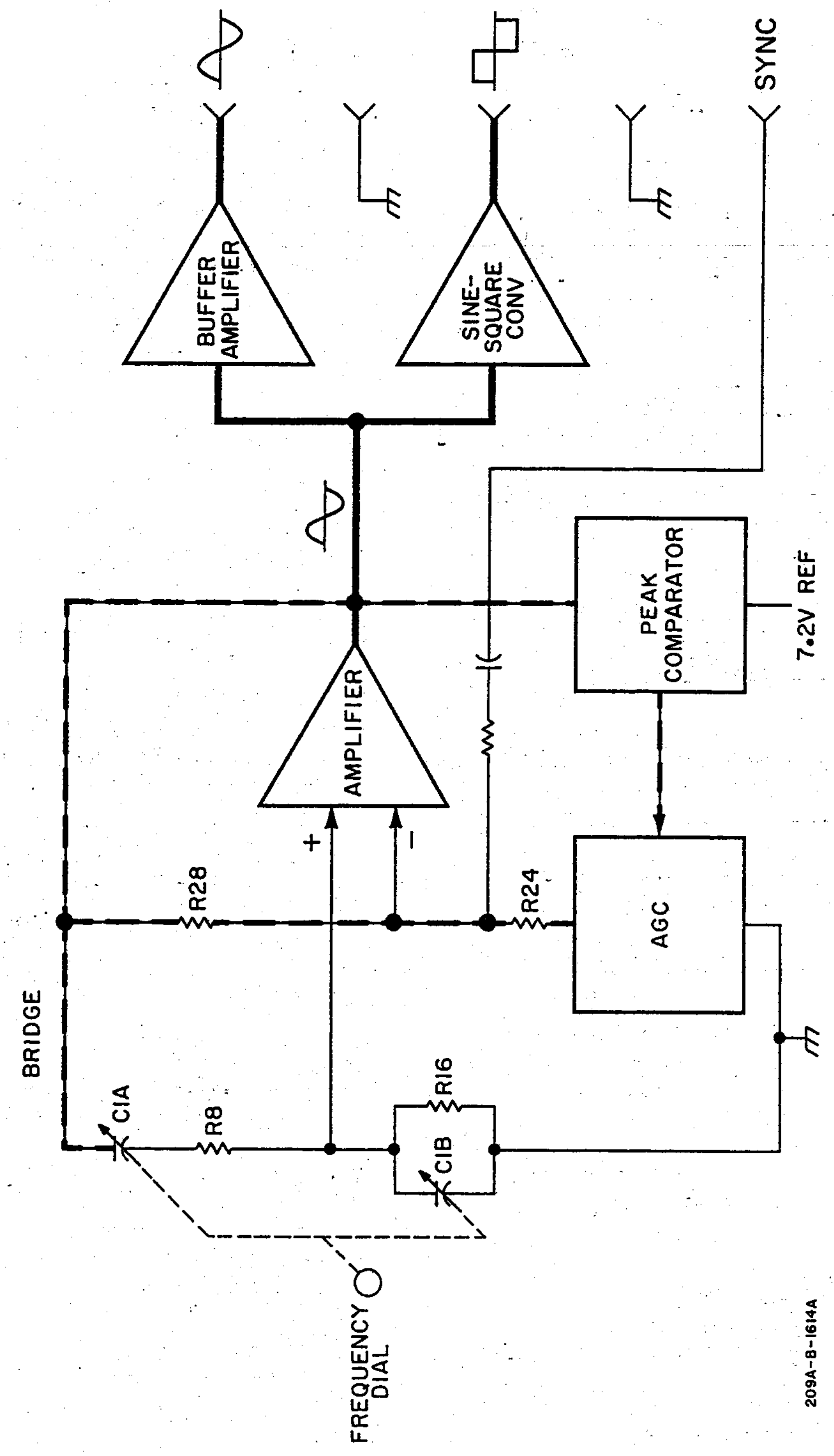


Figure 4-1. Model 209A Block Diagram

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. This section contains a description of the basic principles of circuit operation for the Model 209A. The information is presented as a discussion of each block indicated on the Block Diagram, Figure 4-1, and detailed circuit descriptions which refer to Figure 7-1 and 7-2.

4-3. The Model 209A is basically a Wien bridge oscillator. The output from the oscillator circuit is applied to a buffer amplifier and to a sine wave to square wave converter. These two circuits provide independent sine wave and square wave outputs, respectively.

4-4. BLOCK DIAGRAM DESCRIPTION.

4-5. BRIDGE AND AMPLIFIER.

4-6. An overall loop gain of at least unity is a requirement for any amplifier to oscillate. The Model 209A satisfies this requirement with a combination of positive and negative feedback through the bridge.

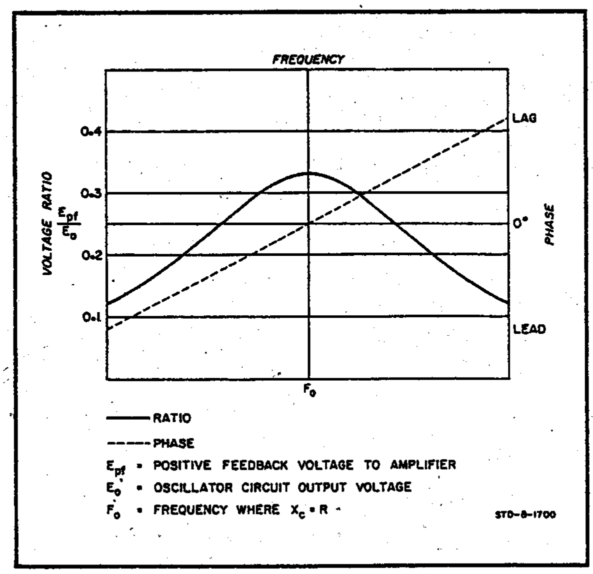


Figure 4-2. RC Frequency Network Characteristics

4-7. The oscillator bridge is divided into two networks, the frequency selective network and the negative feedback network. Positive feedback is furnished through the frequency determining network of C1A, R8, C1B, and R16. At the frequency that the phase of the positive feedback is 0°, X_c = R and the maximum ratio of output voltage is supplied to the amplifier (see Figure 4-2). The characteristics of the Wien bridge are such that the output voltage to the + input of the amplifier at F_o is one third the amplitude of the positive feedback voltage. Therefore, to maintain unity gain and oscillation, the negative feedback network (R28, R24 and AGC) was designed with a divider ratio of two to one, to give the amplifier a gain of three.

4-8. The amplifier itself is a solid-state, high gain amplifier with the output in phase with the input so that feedback will produce oscillations.

4-9. PEAK COMPARATOR AND AGC.

4-10. The voltage output from the Wien bridge to the input of the amplifier is not always one third of the positive feedback voltage at all operating frequencies, nor is the amplifier gain constant for all operating frequencies. One technique used for maintaining unity gain in the oscillator circuit at all operating frequencies is to have a dynamic resistance, variable with changes in gain, in the negative feedback network. In the Model 209A this is accomplished with the combination of the peak comparator and AGC circuits.

4-11. The peak comparator compares the negative peak of the oscillator amplifier output to a 7.2 volt reference. If the output varies above or below the reference voltage, a difference voltage will be supplied to the AGC circuit. The "dynamic resistance" of the AGC circuit is a field-effect transistor with the gate controlled by the difference signal from the peak comparator. The oscillator amplifier output is held to 7.2 volts peak amplitude.

4-12. When the oscillator is first turned on, the AGC gives the amplifier a gain of much greater than three. Noise in the amplifier is amplified greatly, and the frequency selective network in the Wien bridge selects the noise at the tuned frequency. The selected noise becomes positive feedback to the amplifier, and the amplifier starts oscillating at the tuned frequency. As the output amplitude approaches 7.2 volts peak, the

AGC reduces the gain of the amplifier to three; and stable oscillation is achieved.

4-13. BUFFER AMPLIFIER.

4-14. The 5 volt rms sine wave output from the oscillator circuit is coupled to the buffer amplifier. The amplifier has a high open loop gain that is controlled by the negative feedback to provide a gain of 2. This enables the circuit to have very low distortion characteristics. The buffer amplifier uses a complementary symmetry transistor pair to furnish a 10 volt rms output.

4-15. SINE-SQUARE CONVERTER.

4-16. The 5 volt rms sine wave output from the oscillator circuit is also applied to the sine-square converter. The sine wave is coupled to a tunnel diode which produces a small square wave output with fast rise and fall times. This small square wave signal is then shaped and amplified. It appears at the output as a 20 volt peak-to-peak square wave.

4-17. DETAILED CIRCUIT DESCRIPTION.

4-18. For the following paragraphs, refer to the Oscillator Schematic Diagram, Figure 7-1.

4-19. Transistors A1Q1 through A1Q7 make up the basic oscillator amplifier. A1Q1 is an N-channel FET. A1CR1 sets up proper dc bias for A1Q2. Diodes A1CR6, A1CR7, A1CR8 set up proper bias for A1Q4. Capacitor A1C9 is chosen to provide a stable roll off at high frequencies. A1Q7 is a current source for A1Q3 and A1Q4. A1CR4 and A1CR5 provide proper biasing for complementary output transistors A1Q5 and A1Q6.

4-20. The positive feedback arm of the Wien bridge consists of tuning capacitors A1C1A and A1C1B, and range switching resistors A1R1 through A1R17.

4-21. The negative feedback arm of the Wien bridge depends upon the ratio of the impedance of A1R28 to the total impedance of A1R23, A1R24, A1R25, and A1Q8. A1R25 reduces the effect of the FET A1Q8 to increase stability. A1Q8 provides AGC for this amplifier by varying impedance to obtain the proper negative feedback.

4-22. The conduction of FET A1Q8 is controlled by the peak detector circuit using A1Q9. A1Q9 conducts during the most negative portion of each negative half cycle, developing a negative charge in A1C15 and its parallel capacitors. As the amplifier output amplitude increases, A1Q9 conducts more and A1C15 becomes more negatively charged. This makes the FET input voltage more negative, increasing its impedance and increasing the negative feedback to reduce the output amplitude of the amplifier.

4-23. Transistors A1Q13 through A1Q18 comprise a buffer amplifier with a gain of two. A1Q13 and A1Q14 form a differential amplifier. Diodes A1CR18 and A1CR19 furnish proper biasing for complementary output transistors A1Q17 and A1Q18. When the output attenuator A1R79 is fully clockwise, the output amplitude is greater than 10 volts rms. When the attenuator is fully counter-clockwise, the output is attenuated by greater than 20 dB.

4-24. The Sine-Square Converter circuit includes A1Q10 through A1Q12. This converter circuit operates as a saturating amplifier. Tunnel diode A1CR12 squares the sine wave input, and the Symmetry Adjust A1R45 determine the level where conduction starts. This provides for adjustment of the symmetry of the square wave. Zener diode A1CR15 sets the voltage level of the negative portion of the square wave. A1Q12 furnishes the positive portion of the square wave output, and A1Q11 furnishes the negative output.

4-25. POWER SUPPLY.

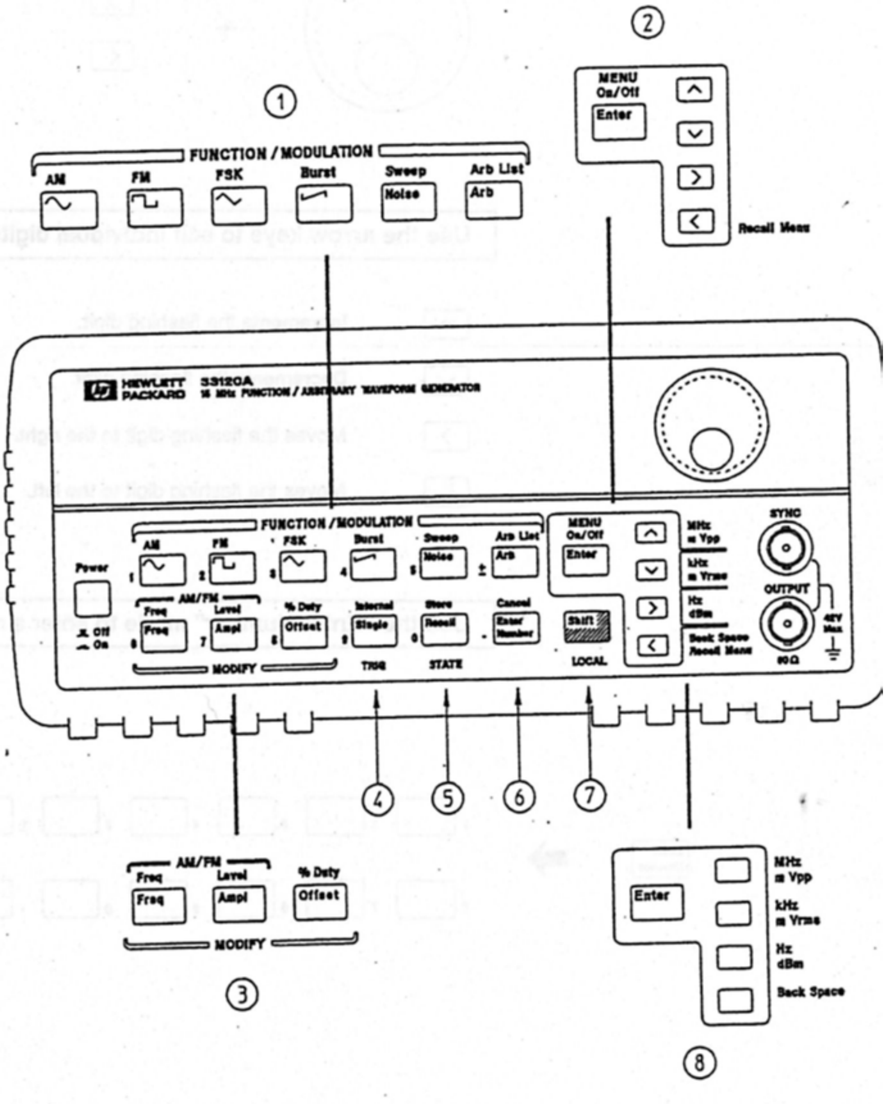
4-26. The following paragraphs refer to the Power Supply Schematic, Figure 7-2.

4-27. This power supply is a series regulated power supply furnishing +21 volts and -21 volts. Zener diode A2CR6 serves as a reference for the positive power supply, which in turn serves as the reference for the negative supply. The positive supply is described here, and the negative supply operates similarly.

4-28. Transistor A2Q1 regulates the output voltage and is controlled by A2Q3. A2Q2 is a current source for A2Q3. Zener diode A2CR5 furnishes bias for A2Q2, while A2R2 injects negative ripple feedback. A2CR6 sets the emitter voltage of A2Q3, setting up a reference for the supply output. A2Q4 current limits the output to prevent damage to the supply.

HP 33120A Function Generator / Arbitrary Waveform Generator

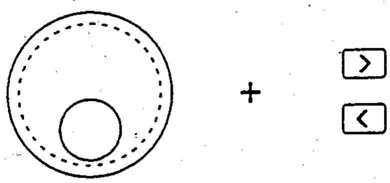
The Front Panel at a Glance



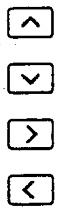
1 Function / Modulation keys
2 Menu operation keys
3 Waveform modify keys
4 Single / Internal Trigger key (*Burst and Sweep only*)
5 Recall / Store instrument state key
6 Enter Number key
7 Shift / Local key
8 Enter Number "units" keys

You can enter numbers from the front-panel using one of three methods.

Use the knob and the arrow keys to modify the displayed number.

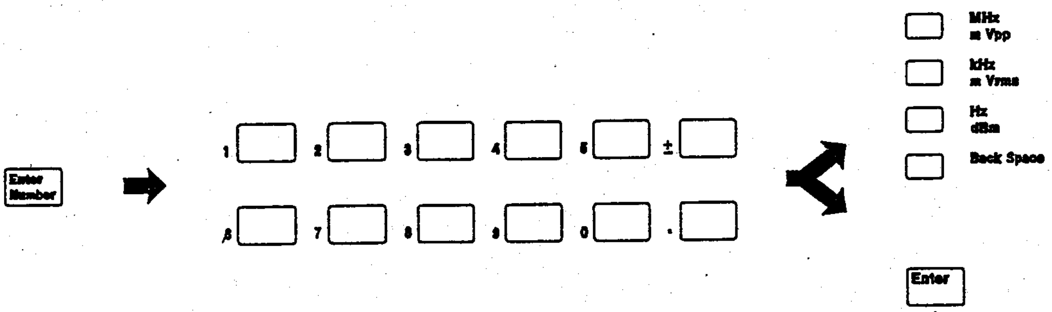


Use the arrow keys to edit individual digits.



- **Increments** the flashing digit.
- **Decrements** the flashing digit.
- Moves the flashing digit to the right.
- Moves the flashing digit to the left.

Use the "Enter Number" mode to enter a number with the appropriate units.



Use "Enter" for those operations that do not require units to be specified (AM Level, Offset, % Duty, and Store/Recall State).

WAVEFORMS

Standard Waveforms:	Sine, Square, Triangle, Ramp, Noise, DC volts, Sine(x)/x, Negative Ramp, Exponential Rise, Exponential Fall, Cardiac
Arbitrary Waveforms:	
Waveform Length:	8 to 16,000 points
Amplitude Resolution:	12 bits (including sign)
Sample Rate:	40 MSa / sec
Non-Volatile Memory:	Four (4) 16k waveforms

FREQUENCY CHARACTERISTICS

Sine:	100 µHz – 15 MHz
Square:	100 µHz – 15 MHz
Triangle:	100 µHz – 100 kHz
Ramp:	100 µHz – 100 kHz
Noise (Gaussian):	10 MHz bandwidth
Arbitrary Waveforms:	
8 to 8,192 points:	100 µHz – 5 MHz
8,193 to 12,287 points:	100 µHz – 2.5 MHz
12,288 to 16,000 points:	100 µHz – 200 kHz
Resolution:	10 µHz or 10 digits
Accuracy:	10 ppm in 90 days, 20 ppm in 1 year, 18°C – 28°C
Temperature Coefficient:	< 2 ppm / °C
Aging:	< 10 ppm / yr

SINEWAVE SPECTRAL PURITY

Harmonic Distortion	
DC to 20 kHz:	-70 dBc
20 kHz to 100 kHz:	-60 dBc
100 kHz to 1 MHz:	-45 dBc
1 MHz to 15 MHz:	-35 dBc
Total Harmonic Distortion	
DC to 20 kHz:	0.04%
Spurious (non-harmonic)	
Output (DC to 1 MHz):	< -65 dBc
Output (> 1 MHz):	< -65 dBc + 6 dB/octave
Phase Noise:	< -55 dBc in a 30 kHz band

SIGNAL CHARACTERISTICS

Square wave	
Rise/Fall Time:	< 20 ns
Overshoot:	< 2%
Asymmetry:	1% + 5 ns
Duty Cycle:	20% to 80% *(to 5 MHz)* 40% to 60% *(to 15 MHz)*
Triangle, Ramp, Arb	
Rise/Fall Time:	100 ns *(typical)*
Linearity:	< 0.1% of peak output
Settling Time:	< 250 ns to 0.5% of final value
Jitter:	< 25 ns

OUTPUT CHARACTERISTICS (1)

Amplitude (into 50Ω): (2)	50 mVpp – 10 Vpp
Accuracy (at 1 kHz):	± 1% of specified output
Flatness	*(sine wave relative to 1 kHz)*
< 100 kHz:	± 1% (0.1 dB)
100 kHz to 1 MHz:	± 1.5% (0.15 dB)
1 Mz to 15 MHz:	± 2% (0.2 dB)
Offset (into 50Ω): (3)	± 5 Vpk ac + dc
Accuracy: (4)	± 2% of setting + 2 mV
Output Impedance:	50 ohms fixed
Resolution:	3 digits, Amplitude and Offset
Output Units:	Vpp, Vrms, dBm
Isolation:	42 Vpk maximum to earth
Protection:	Short-circuit protected ± 15 Vpk overdrive < 1 minute

(1) Add 1/10th of output amplitude and offset specification per °C for operation outside of 18°C to 28°C range.

(2) 100 mVpp – 20 Vpp amplitude into open-circuit load.

(3) Offset ≤ 2 X peak-to-peak amplitude.

(4) For square wave outputs, add 2% of output amplitude additional error.

MODULATION CHARACTERISTICS

AM Modulation

Carrier -3 dB Freq:	15 MHz *(typical)*
Modulation:	Any internal waveform plus Arb
Frequency:	10 mHz to 20 kHz (±0.05% to 2.5 kHz, then decreases linearly to ±0.4% at upper limit)
Depth:	0% to 120%
Source:	Internal / External

FM Modulation

Modulation:	Any internal waveform plus Arb
Frequency:	10 mHz to 10 kHz (±0.05% to 600 Hz, then decreases linearly to ±0.8% at upper limit)
Peak Deviation:	10 mHz to 15 MHz
Source:	Internal Only

Burst Modulation

Carrier Frequency:	5 MHz max.
Count:	1 to 50,000 cycles, or Infinite
Start Phase:	-360° to +360°.
Internal Rate:	10 mHz to 50 kHz ±1%
Gate Source:	Internal or External Gate (1)
Trigger Source:	Single, External, or Internal Rate

FSK Modulation

Frequency Range:	10 mHz to 15 MHz (±0.05% to 600 Hz, then decreases linearly to ±4% at upper limit)
Internal Rate:	10 mHz to 50 kHz
Source:	Internal / External (1 MHz max.)

FREQUENCY SWEEP

Type:	Linear or Logarithmic
Direction:	Up or Down
Start F / Stop F:	10 mHz to 15 MHz
Time:	1 ms to 500 sec ±0.1%
Source:	Single, External, or Internal

REAR-PANEL INPUTS

External AM Modulation:	± 5 Vpk = 100% Modulation 5 kΩ Input Resistance
External Trigger/FSK Burst Gate: (1)	TTL (low true)
Latency:	1.3 µs
Jitter:	25 ns

SYSTEM CHARACTERISTICS

Configuration Times (2)

Function Change: (3)	80 ms
Frequency Change: (3)	10 ms
Amplitude Change:	30 ms
Offset Change:	10 ms
Select User Arb:	100 ms
Modulation Parameter Change:	< 350 ms

Arb Download Times over HP-IB:

Arb Length	*Binary*	*ASCII Integer*	*ASCII Real* (4)
16,000 points	8 sec	81 sec	100 sec
8,192 points	4 sec	42 sec	51 sec
4,096 points	2.5 sec	21 sec	26 sec
2,048 points	1.5 sec	11 sec	13 sec

Arb Download Times over RS-232 at 9600 Baud: (5)

Arb Length	*Binary*	*ASCII Integer*	*ASCII Real* (6)
16,000 points	35 sec	101 sec	134 sec
8,192 points	18 sec	52 sec	69 sec
4,096 points	10 sec	27 sec	35 sec
2,048 points	6 sec	14 sec	18 sec

(1) Trigger source ignored when External Gate is selected.

(2) Time to change parameter and output the new signal.

(3) Modulation or sweep off.

(4) Times for 5-digit and 12-digit numbers.

(5) For 4800 baud, multiply the download times by two;
For 2400 baud, multiply the download times by four, etc.

(6) Time for 5-digit numbers. For 12-digit numbers, multiply the 5-digit numbers by two.

GENERAL SPECIFICATIONS

Power Supply: (1) 100V / 120V / 220V / 240V ±10% *(switch selectable)*

Power-Line Frequency: 45 Hz to 66 Hz and 360 Hz to 400 Hz. Automatically sensed at power-on.

Power Consumption: 50 VA peak (28 W average)

Operating Environment: 0°C to 55°C
80% Relative Humidity to 30°C

Storage Environment: -40°C to 70°C

State Storage Memory: Power-off state automatically saved. Three (3) User-Configurable Stored States, Arbitrary waveforms stored separately.

Dimensions (W x H x D)
Bench Top: 254.4 mm x 103.6 mm x 374 mm
Rack Mount: 212.6 mm x 88.5 mm x 348.3 mm

Weight: 4 kg (8.8 lbs)

Safety Designed to: EN61010, CSA1010, UL-1224

EMC: EN55011, EN50082-1, MIL-461C (2)

Vibration and Shock: MIL-T-28800E, Type III, Class 5

Acoustic Noise: 30 dBa

Warm-Up Time: 1 hour

Warranty: 3 years standard

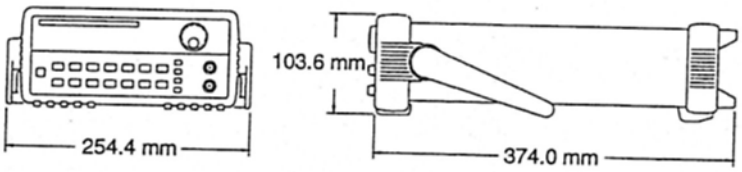
Remote Interface: IEEE-488 and RS-232 standard

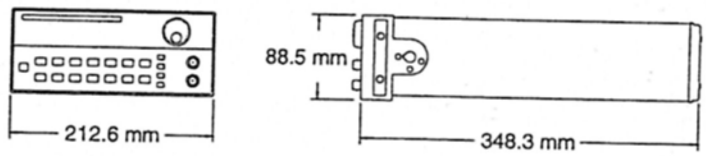
Programming Language: SCPI-1993, IEEE-488.2

Accessories Included: User's Guide, Service Guide, Quick Reference Card, Test Report, and power cord.

(1) For 400 Hz operation at 120 Vac, use the 100 Vac line-voltage setting.

(2) The HP 33120A does not meet the performance requirements of MIL-461C characterization. However, performance test data is available upon request.





SECTION I

1. INTRODUCTION

This instrument is a 20Hz to 200KHz audio oscillator with a built-in four digit digital frequency counter. This instrument generates low distortion sine waves and square waves over a frequency range of 20Hz to 200KHz. A stable RC oscillator provides 5Vrms output under no load, or 2.5Vrms into 600Ohms load.

A continuously variable control affords greater than 50dB sine wave attenuation in addition to the push button-selected 10, 20, 40 dB steps. A fixed TTL square wave, at the same frequency as the sine wave, is used at the TTL output BNC in the front panel. The oscillator also features an external synchronizing input BNC which locks the output frequency to a synchronizing signal. A single dial and four range pushbuttons provide the frequency selection.

2. SPECIFICATIONS

A. Frequency range

- 200 Range : 20Hz ~ 200Hz
- 2K Range : 200Hz ~ 2KHz
- 20K Range : 2KHz ~ 20KHz
- 200K Range : 20KHz ~ 200KHz

B. Sine wave characteristics

- Output voltage: 5 Vrms or more at no load
  2.5Vrms or more into 600 ohms.
- Distortion factor (at max. out)
  200 Range : 0.5% or less
  2K Range : 0.15% or less
  20K Range : 0.15% or less
  200K Range : 0.5% or less
- Output impedance : 600 Ohms ± 10%
- Output attenuator : 0 to greater than 50dB continuously variable.
  10dB, 20dB and 40dB steps within ±3% for each step.

C. Square wave characteristics (TTL out)

- Over shoot : 2% or less (at 1 KHz)
- Duty ratio : 50% ± 5% (at 1 KHz)
- Output level : Fixed amplitude
  Logic 0 less than 0.4V
  Logic 1 more than 2.4V
- Rise & Fall time : less than 200nSec

D. External synchronization characteristics

- Input impedance : approx. 10 Kohms
- Max. input voltage : 10 Vrms

E. Frequency counter characteristics

- Display : 4 digits, 7mm red LED display.
- Measuring range : 10Hz ~ 1MHz
- Reading accuracy : 0.01% ± 1 count
- Sensitivity : 800mVrms, 10Hz to 100Hz
  300mVrms, 100Hz to 1KHz
  80mVrms, 1KHz to 10KHz
  50mVrms, 10KHz to 100KHz
  25mVrms, 100KHz to 1MHz
- Max. input voltage: 150 Vp-p
- Input impedance : 1 Mohm

F. General

- Power requirements : 110/120/220V ± 10%
  240V + 5%, − 10%, 48 ~ 66Hz
  Voltage is selected by voltage selector at rear panel.
- Operating temperature: 0°C ~ 50°C (Accuracy is specified at 25 ± 5°C)
- Dimension : 205(W)x76(H)x267(D) mm
- Weight : 2,270 g

HUNG CHANG
8204 A

SECTION II

1. INTRODUCTION

This section contains information and instructions necessary for the operation of the oscillator. This section also describes the operating characteristics.

2. PANEL FEATURES

The front and rear panel controls are shown in Fig. 2-1 and Fig. 2-2. The description of each control and connector is keyed to the number shown in the Figure

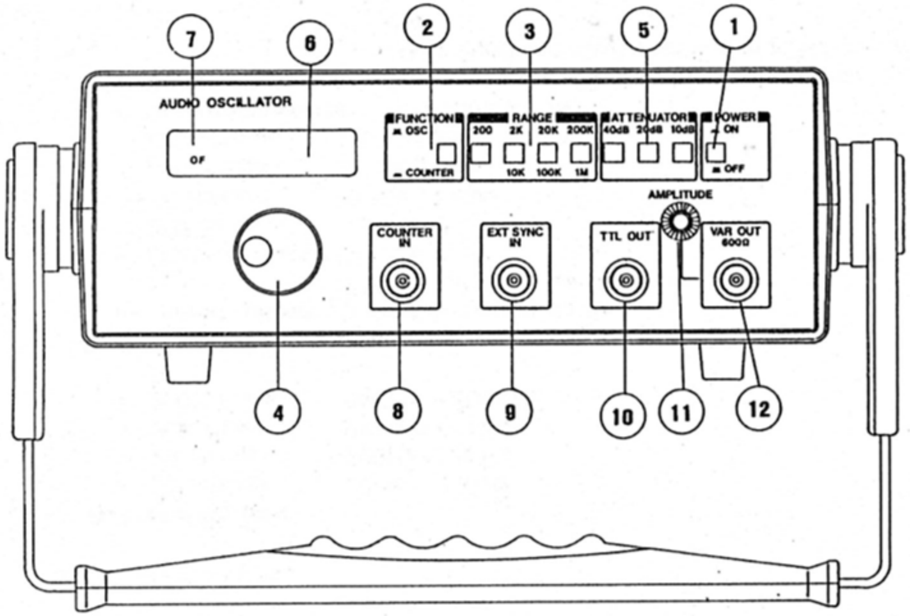


Fig. 1-1 Front panel feature

1) POWER : Connect AC power to the oscillator.
2) FUNCTION : Select the function to audio oscillator or counter.
(The release statement (⎍) to operate as a oscillator.
The push statment (⌴) to operate as a counter.)
3) RANGE : Select the range of output frequency or external input frequency.
(Output frequency range : 200; 20Hz~200Hz, 2K; 200Hz~2KHz, 20K; 2kHz~20KHz, 200K; 20KHz~200KHz.
Input frequency range : 10K; 10Hz~10KHz, 100K; 10KHz~100KHz, 1M; 100KHz~1MHz.)
4) FREQUENCY CONTROL : Control the output frequency in selected range.

5) ATTENUATOR : Select attenuation of 0 dB to 70 dB by combining each attenuator (10 DB, 20 dB, 40 dB).
6) DISPLAY : Display the output or input frequency.
7) O.F. LED : Lights and flickers when the input frequency is overflow.
8) COUNTER IN : Input connector for measuring the unknown external signal.
9) EXT. SYNC. IN : Input connector for the external synchronization signal.
10) TTL OUT : Output connector for square wave (TTL level).
11) VAR OUT : Output connector for sine wave. The output impedance is 600 ohms.
12) AMPLITUDE : Continuously varies the amplitude of sine wave output.

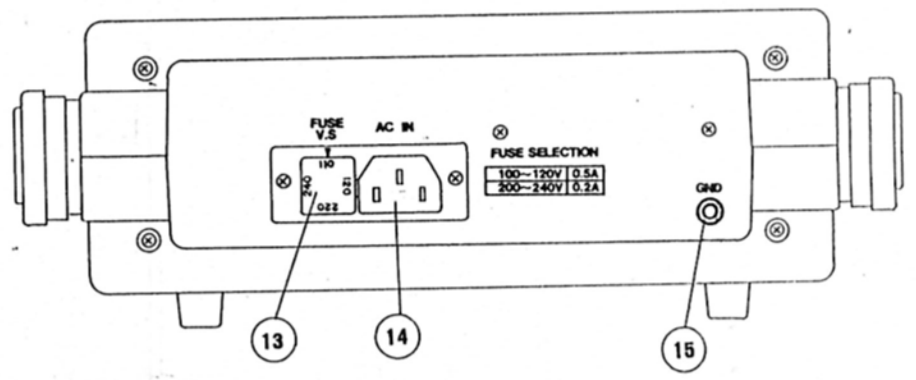


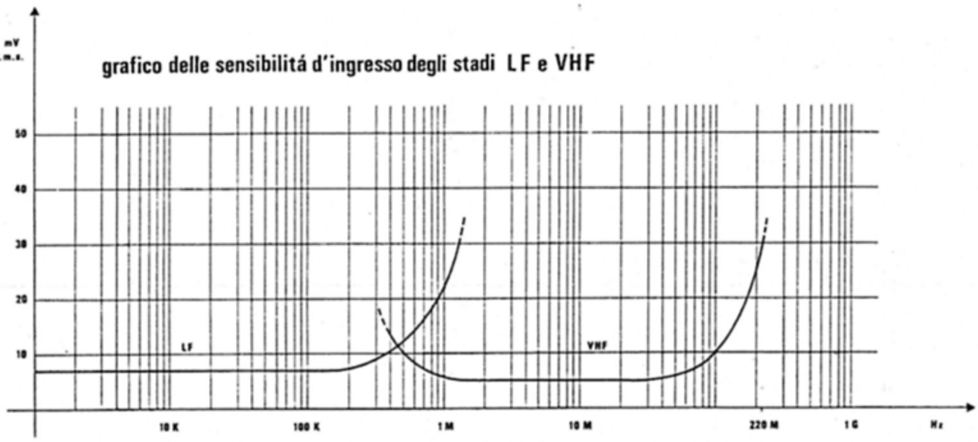
Fig. 1-2 Rear panel feature

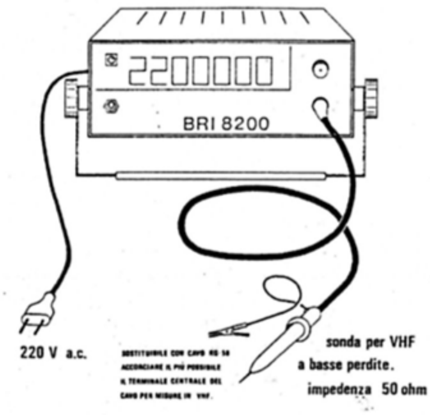
13) VOLTAGE SELECTOR : Selects the AC line voltage.
14) AC INLET : Provides connection to AC power.
15) GND TERMINAL

BREMI

Elettronica Medica Industriale

Costruzione apparecchiature: Elettroniche industriali - Elettroniche medicali
43100 PARMA - Via Pasubio, 3/C - Tel. 0521/72209-771573 - Telex 530259 CCIAPR-I for Bremi





FREQUENZIMETRO DIGITALE MOD. BRI 8200

Gamma di frequenza: 1 Hz - 220 MHz
Display: 7 cifre a Led altezza 1/2"
Tempo di gate: 1 sec.
Precisione: ± 1 digit ± la precisione del quarzo
Alimentazione: 220 V a.c. 50 Hz

CARATTERISTICHE INGRESSO LF

Impedenza: 1 MOHM
Gamma di frequenza: 1 Hz - 2,5 MHz
Tensione Max in ingresso: 150 V di picco
Risoluzione: 1 Hz
Sensibilità: 25 mV RMS

CARATTERISTICHE INGRESSO VHF

Impedenza: 50 OHM
Gamma di frequenza: 1,5 MHz - 220 MHz
Tensione Max in ingresso: 5 V di picco (0,25 W)
Risoluzione: 100 Hz
Sensibilità:
7 mV RMS fino a 200 KHz
10 mV RMS da 200 KHz a 400 KHz
25 mV RMS da 400 KHz a 1 MHz

CARATTERISTICHE BASE TEMPI INTERNA

Frequenza: 5,24288 MHz
Stabilità in funzione delle variazioni di rete: ± 1ppm per ± 10% variazione

CARATTERISTICHE GENERALI

Temperatura di funzionamento: 0°C - 45°C
Mobile: con maniglia anodizzata. Il contenitore è in lamiera 10/10 e in alluminio 30/10 con verniciatura epossidica
Dimensioni: 245 x 220 x 70 mm.
Peso: 1900 gr.
Garanzia: 1 anno

DIGITAL FREQUENCYMETER MOD. BRI 8200

Frequency range: 1 Hz - 220 MHz
Display: 7 digit 1/2" Led
Gate Time: 1 sec.
Accuracy: ± 1 count ± time base accuracy
Power requirement: 220V a.c. 50 Hz

LF INPUT CHARACTERISTICS

Impedance: 1 MOHM
Range of frequency: 1 Hz to 2,5 MHz
Resolution: 1 Hz
Sine wave sensitivity: 25 mV RMS
Maximum input voltage: 150 V peak

VHF INPUT CHARACTERISTICS

Impedance: 50 OHM
Range of frequency: 1,5 MHz to 220 MHz
Resolution: 100 Hz
Maximum input voltage: 5 V peak (0,25 W)
Sine wave sensitivity:
7 mV RMS up to 200 KHz
10 mV RMS from 200 KHz to 400 KHz
25 mV RMS from 400 KHz to 1 MHz

INTERNAL TIME BASE

Frequency: 5,24288 MHz
Stability with voltage variations: ± 1ppm for ± 10% line voltage variation

GENERAL SPECIFICATIONS

Temperature range: 0°C to 45°C
Cabinet: with anodized handles, 10/10 sheet metal and 30/10 aluminium container with epoxy-based paint.
Dimensions: 245 x 220 x 70 mm.
Weight: 1900 gr.
Guarantee: one year

DIGITAL-FREQUENZMESSER MOD. BRI 8200

Frequenzbereich: 1 Hz - 220 MHz
Display: 7 Ziffern mit LED Höhe 1/2"
Gate-Zeit: 1 Sekunde
Präzision: ± 1 Zählung ± Quarzgenauigkeit
Speisung: 220 Vac 50 Hz

EINGANG LF

Impedanz: 1 MOHM
Frequenzbereich: 1 Hz - 2,5 MHz
Auflösung: 1 Hz
Empfindlichkeit: 25 mV RMS
Maximale Eingangsspannung: Höchst 150V

EINGANG VHF

Impedanz: 50 OHM
Frequenzbereich: 1,5 MHz - 220 MHz
Auflösung: 100 Hz
Maximale Eingangsspannung: Höchst 5V (0,25 W)
Empfindlichkeit:
7 mV RMS bis 200 KHz
10 mV RMS von 200 KHz to 400 KHz
25 mV RMS von 400 KHz to 1 MHz

INNERE ZEITENBASIS

Frequenz: 5,24288 MHz
Stabilität in Abhängigkeit der Netzschwankungen: ± 1ppm auf ± 10% Schwankung

ALLGEMEINE-EIGENSCHAFTEN

Betriebstemperatur: 0°C - 45°C
Gehäuse: mit eloxierte griffe. Behalter aus 10/10 Blech 30/10 Aluminium mit Epoxydlackierung
Abmessungen: 245 x 220 x 70 mm.
Gewicht: 1900 gr.
Garantie: ein jahr

Table 1-1. Specifications

INPUT CHARACTERISTICS

Range:
Channel A 10 Hz to 100 MHz
Channel B 10 Hz to 2.5 MHz

Sensitivity:
Channel A:
25 mV rms to 100 MHz
75 mV peak-to-peak minimum pulse with 5 ns
Channel B:
25 mV rms to 2.5 MHz
75 mV peak-to-peak minimum pulse width of 50 ns

Coupling: AC

Impedance: 1 MΩ **NOMINAL** shunted by less than 30 pF

Attenuator: X1 or X20 **NOMINAL** (A Channel only)

Trigger Level:
Continuously variable ±350 mV times attenuator setting around average value os signal.

Slope: Independent selection of + or – slope

Channel Input: Selectable SEPARATE or COMMON A

Damage Level:

X1:	DC to 100 kHz	350V (DC + peak AC)
	100 kHz to 5 MHz	2.5×10^7C × Hz Product
	Above 5 MHz	5V rms
X20:	DC to 1 MHz	350V (DC + Peak AC)
	1 MHz to 50 MHz	2.5×10^8V × Hz Product
	Above 50 MHz	5V rms

FREQUENCY (A)

Range:
10 Hz to 10 MHz direct count
1 MHz to 100 MHz prescaled by 10

LSD Displayed: Direct count 0.1 Hz, 1 Hz, 10 Hz switch selectable. Prescaled 10 Hz, 100 Hz, 1 kHz switch selectable.

Resolution: ± LSD

Accuracy: ± LSD ± (time base error) × FREQ

PERIOD (A)

Range: 10 Hz to 2.5 MHz

LSD Displayed:

$\frac{100 \text{ ns}}{N}$ for N=1 to 1000 in decade steps of N

Resolution:

$$\pm \text{LSD} \pm 1.4 \times \frac{\text{Trigger Error}}{N}$$

Accuracy

$$\pm \text{LSD} \pm 1.4 \times \frac{\text{Trigger Error}}{N}$$

± (time base error) × PER

TIME INTERVAL (A TO B)

Range: 250 ns to 1 s

LSD Displayed: 100 ns

Resolution: ± LSD ± START Trigger Error ± STOP Trigger Error

Accuracy: ± LSD ± START Trigger Error ± STOP Trigger Error ± (time base error) × TI

Time Interval measurements require an arming signal for both the START and STOP Channels. (See Paragraph 3-11.)

RATIO

Range:
10 Hz to 10 MHz Channel A
10 Hz to 2.5 MHz Channel B

LSD Displayed:

1 part in $\frac{A}{B} \times N$ in decade steps of N for N=1 to 1000

Resolution:
± LSD ± (B Trigger Error × FREQUENCY A)/N

Accuracy:
± 1 count of A ± (B Trigger Error × FREQUENCY A)/N

TOTALIZE (A)

Range: 10 Hz to 10 MHz

Resolution: ± 1 count of input

GENERAL

Check: Counts internal 10 MHz Oscillator

Display: 7-digit amber LED display with gate and overflow indication.

Maximum Sample Rate: 5 readings per second.

Operating Temperature: 0° to 50°C

Power Requirement:
115V, +10%, –25%; 230V, –17%, +9%; 48–66 Hz; 10 VA maximum.

Weight: 2.0 kg (4.4 lbs.)

Dimension: 238 mm wide × 98 mm high × 276 mm long (9⅜ × 3⅜ × 10⅞ in.)

TIME BASE

Frequency: 10 MHz

Aging Rate: <3 parts in 10^7 per month

Temperature: <±1 part in 10^5, 0° to 50°C

Line Voltage: <±1 part in 10^7 for ±10% variation.

OPTIONS

Option 001: High Stability Time Base (TCXO)

Frequency: 10 MHz

Aging Rate: <1 part in 10^7 per month

Temperature: <±1 part in 10^6, 0° to 40°C

Line Voltage: <±1 part in 10^8 for ±10% variation

Option 002: Battery

Type: Recharageable lead-acid (sealed)

Capacity: TYPICALLY 8 hour of continuous operation at 25°C.

Recharging Time: TYPICALLY 16 hours to 98% of full charge, instrument nonoperating. Charging circuitry included with option. Batteries not charged during instrument operation.

Battery Voltage Sensor: Automatically shuts instrument off when low battery condition exists.

Line Failure Protection: Instrument automatically switches to batteries in case of line failure.

Weight: Option 002 adds 1.5 kg (3.3 lbs.) to weight of instrument.

WARRANTY

ALL COMPONENTS WITHIN OPTION 002, EXCEPT THE BATTERY, ARE WARRANTED FOR ONE FULL YEAR. BATTERY BT1 (HP PART NO. 1420-0253) IS WARRANTED FOR 90 DAYS.

DEFINITIONS

Resolution: Smallest discernible change of measurement result due to a minimum change in the input.

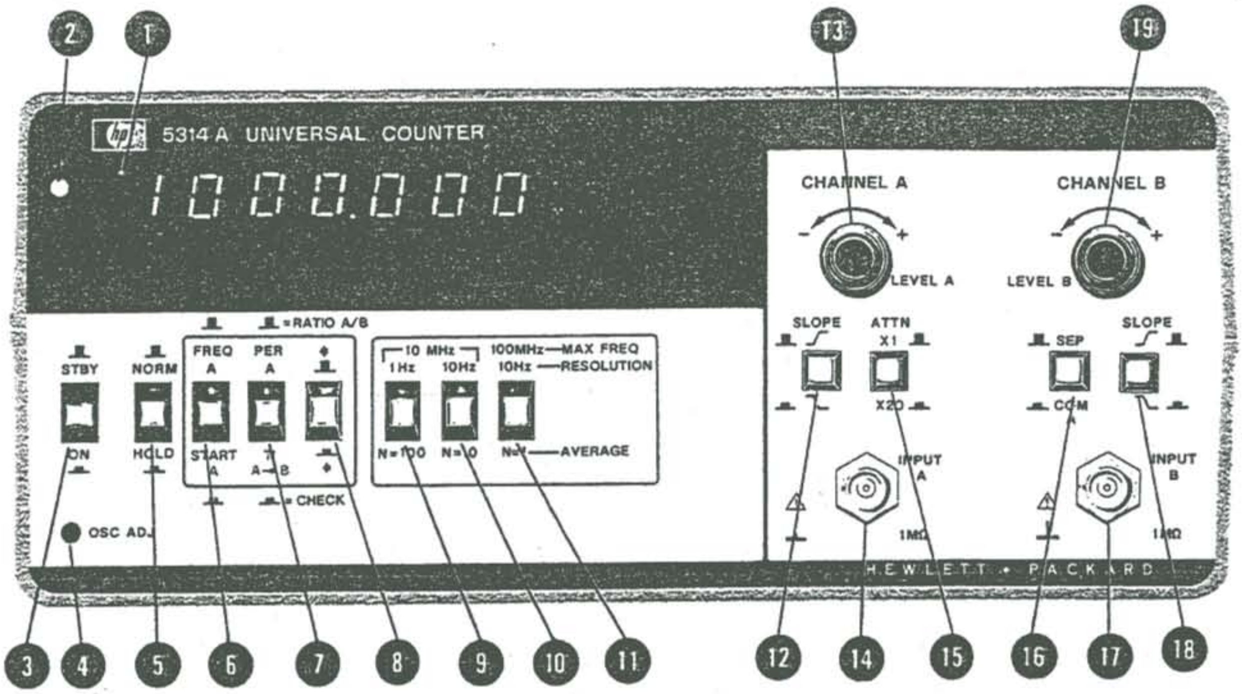
Accuracy: Deviation from the actual value as fixed by universally accepted standard of frequency and time.

Trigger Error:

$$\frac{\sqrt{(80\ \mu V)^2 + e_n{}^2}}{\text{Input Slew Rate at Trigger Point } (\mu V/s)} \text{ (rms)}$$

Where e_n is the rms noise of the input for a 100 MHz bandwidth on Channel A and a 10 MHz bandwidth on Channel B

LSD: Least Significant Digit.



NOTE

See *Table 1-1* for the specifications on all input signals concerning bandwidth, accuracy, and amplitude.

1. Set line switch (3) to the ON position.
2. Set COM A/SEP switch (16) to SEP position.
3. Connect the input signal to INPUT A jack (14).
4. Press FREQ A/START A switch (6) IN. Be sure the blue shift key (8) is in the OUT position. This selects the top function of switch (6).
5. Set SLOPE (12), ATTN (15), and LEVEL A (13) to desired positions; see *Table 1-1*, Specifications, for details.
6. Select either 1 Hz (9) or 10 Hz (10) resolution for frequencies between 10 Hz and 10 MHz. NOTE: 10 Hz (11) may also be used. For frequencies higher than 10 MHz, the 100 MHz/10 Hz switch (11) must be pressed IN.

NOTE

The following three resolutions are available with the HP 5314A but are not printed on the front panel.

A. For 0.1 Hz resolution (10 second gate time) on frequenices from 10 Hz to 10 MHz, place all three resolution switches (9) (10) (11) in the OUT position.

B. For 100 Hz resolution (0.1 second gate time) on frequencies to 100 MHz, place switches (9) and (11) in the IN position.

C. For 1 kHz resolution (0.01 second gate time) on frequencies to 100 MHz, place switches (10) and (11) in the IN position.

Figure 3-3. Frequency Measurement Setup

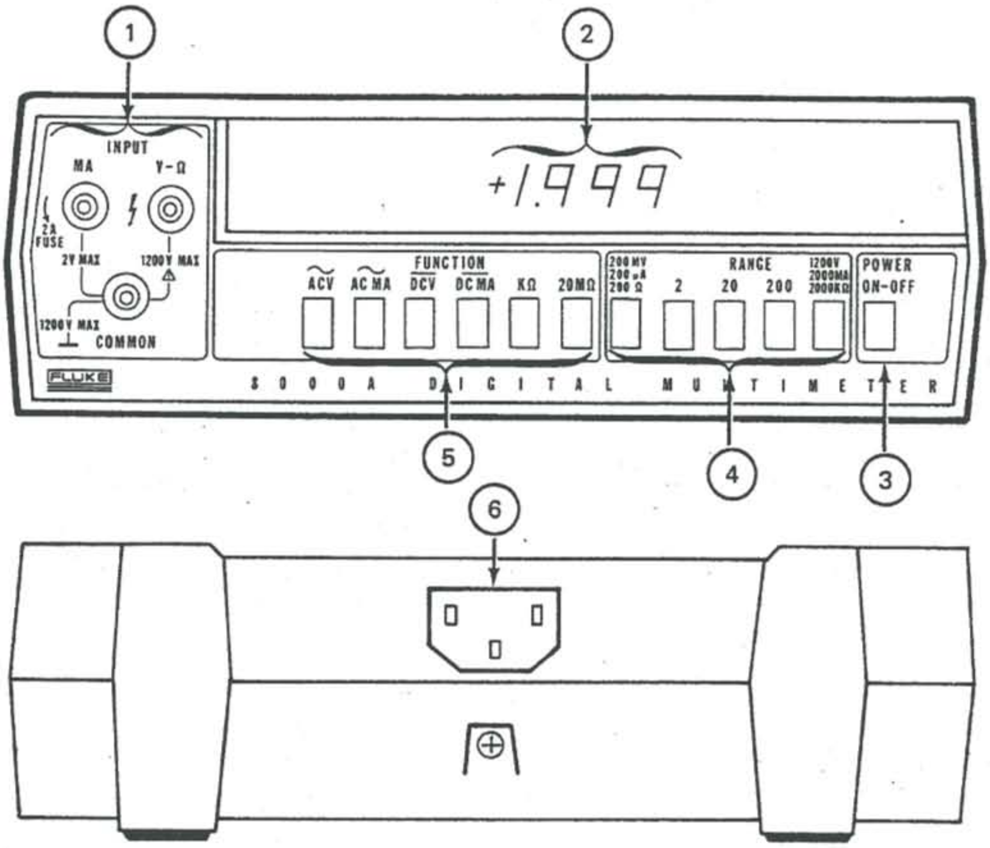


Figure 2-1. 8000A CONTROLS, INDICATORS AND CONNECTORS

Table 2-1. 8000A CONTROLS, INDICATORS AND CONNECTORS

FIG. 2-1 REF. NO.	NAME	FUNCTION
1	INPUT Connectors	Provides the input connections necessary to make current (MA), voltage (V), or resistance (Ω) measurements. All measurements are referenced to the COMMON INPUT connector.
2	Digital Readout	Provides a 3½ digit display (1999 maximum) of the measured input. The readout also includes a properly positioned decimal point, and a + or — sign for dc voltage and current measurements.
3	POWER Switch	Switches the 8000A on or off. The instrument is turned-on when the switch is depressed.
4	RANGE Switches	Provide pushbutton selection of one-of-five ranges which correspond to the selected function (current, voltage, or resistance). The available ranges are: Voltage: 200 MV, 2, 20, 200 and 1200V Current: 200μA, 2, 20, 200 and 2000 MA Resistance: 200Ω, 2, 20, 200 and 2000kΩ
5	FUNCTION Switches	Provide pushbutton selection of one-of-six measurement functions; ACV, AC MA, DCV, DC MA, KΩ, or 20MΩ.
6	Input Power Connector	Provides the means of connecting the instrument through the power cord to the ac power line.

1-9. SPECIFICATIONS

DC Voltage

Ranges	±199.9 mV, ±1.999V, ±19.99V, ±199.9V, ±1199V
Accuracy: 1 year, 15°C to 35°C	±(0.1% of reading +1 digit)
Input Impedance	10 Megohms, all ranges
Normal Mode Rejection	Greater than 60 dB @ 50 Hz, 60 Hz
Common Mode Rejection (1 kΩ unbalance)	Greater than 120 dB @ dc and 50 Hz, 60 Hz
Response Time	500 ms
Maximum Input Voltage	1200V dc or 1200V rms (sinusoidal)

AC Voltage

Ranges	199.9mV, 1.999V, 19.99V 1199V
Accuracy: 1 year, 15°C to 35°C	45 Hz to 10 kHz ±(0.5% +2 digits) 10 kHz to 20 kHz ±(1% +2 digits)
Input Impedance	10 megohms in parallel with 100 pf
Common Mode Rejection (1 kΩ unbalance)	Greater than 60 dB @ 50 Hz, 60 Hz
Response Time (within one range)	3 seconds, worst case
Maximum Input Voltage	1200V rms (sinusoidal), not to exceed 10^7 volts - Hz product on 20, 200, 1200V ranges, 500V rms (sinusoidal) on 200mV and 2V range

Direct Current

Ranges	±199.9µA, ±1.999mA, ±19.99 mA, ±199.9 mA, ±1999mA
Accuracy: 1 year, 15°C to 35°C	±(0.3% of reading +1 digit)
Voltage Burden	0.3V maximum on all ranges except 0.6V on 2000mA range
Response Time	500 ms
Maximum Input	2 Amps rms (fuse protected)

Alternating Current

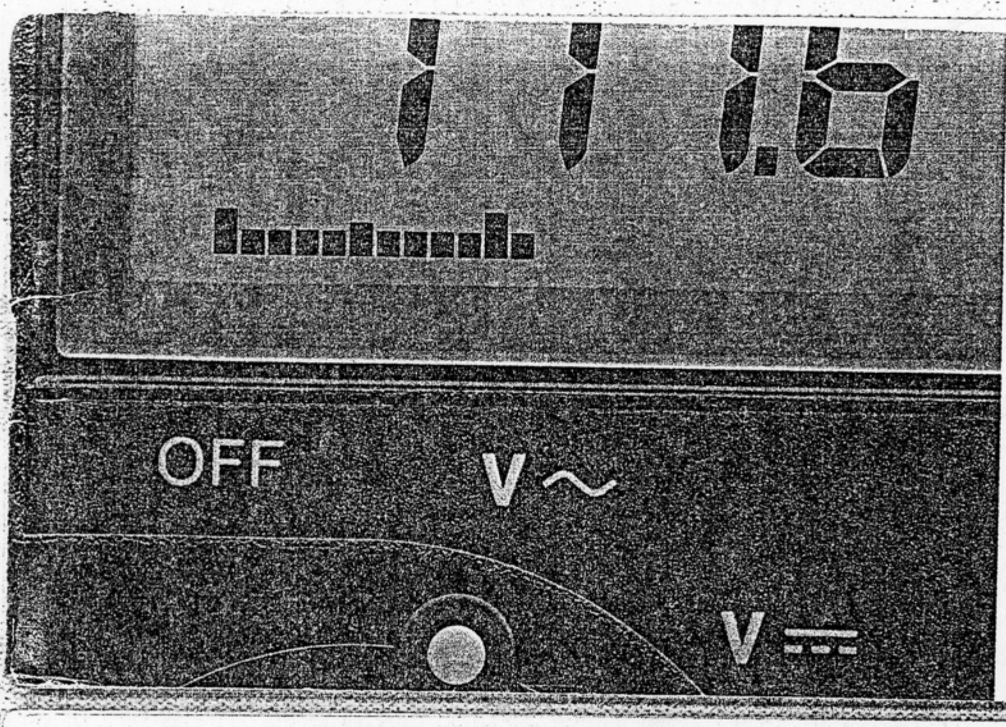
Ranges	199.9µA, 1.999mA, 19.99mA, 199.9mA, 1999mA
Accuracy: 1 year, 15°C to 35°C	45 Hz to 10 kHz ±(1.0% of reading +2 digits) except 2000 mA range 45 Hz to 3 kHz ±(1.0% of reading +2 digits) on 2000 mA
Voltage Burden	0.25V maximum on all ranges except 0.5V on 2000 mA range
Response Time (within one range)	3 seconds
Maximum Input	2 Amps rms (fuse protected)

Resistance

Ranges	199.9Ω, 1.999kΩ, 19.99kΩ, 199.9kΩ, 1999kΩ, 19.99MΩ	
Accuracy: 1 year, 15°C to 35°C	200Ω, 2kΩ, 20kΩ, 200kΩ, 2000kΩ ranges ±(0.2% of reading +1 digit) 20MΩ range ±(0.5% of reading +1 digit)	
Response Time	200Ω, 2kΩ, 20kΩ, 200kΩ, 2000kΩ ranges: 500 ms 20MΩ range: 4 seconds	
Current through Unknown	200Ω Range	1mA
	2kΩ Range	1mA
	20kΩ Range	100µA
	200kΩ Range	1µA
	200kΩ Range	1µA
	20MΩ Range	0.1µA
Maximum Input Voltage	200Ω and 2kΩ Ranges	130V rms
	20kΩ thru 20MΩ Ranges	250V rms

Temperature Coefficients (−10°C to 15°C and 35°C to 55°C)

DC V	±(0.01% reading/°C +.005% F.S./°C)
DC MA	±(0.015% reading/°C + 0.005% F.S./°C)
KΩ	±(0.015% reading/°C + 0.005% F.S./°C)
10 Meg	±(0.02% reading/°C +0.005% F.S./°C)
AC V	±(0.01% reading/°C +0.005% F.S./°C)
AC MA	±(0.015% reading/°C + 0.005% F.S./°C)



FLUKE 73
MULTIMETER

OPERATOR'S MANUAL
MANUEL D'INSTRUCTION
BEDIENUNGS-HANDBUCH

FLUKE

DATI TECNICI

Temperatura d'impiego	Da 0°C a 50°C
Temperatura di conservazione	Da −40°C a +60°C
Umidità relativa Tutte le gamme eccetto 32 MΩ Sola gamma 32Ω	Da 0% a 90% (Da 0°C a 35°C) Da 0% a 70% (Da 35°C a 50°C) Da 0% a 80% (Da 0°C a 35°C) Da 0% a 70% (Da 35°C a 50°C)
Coefficiente di temperatura	0,1 × (precisione specificata)/°C (applicabile da 0°C a 18°C e da 28°C a 50°C)
Tipo di pila	NEDA 1604 9V ı 6F 22 9V
Durata della pila (tipica)	1600 ore (Zn-C) 2000+ ore (alcalina)
Dimensioni (alt. × largh. × lungh.)	2,84 × 7,49 × 16,64 cm (1,12 × 2,95 × 6,55 in)
Peso	0,34 kg (12 oz)
Omologazione sicurezza	Classe di protezione II (IEC 348)

FUNZIONE	GAMMA	RISOLUZIONE	PRECISIONE	CADUTA DI TENSIONE A FONDO SCALA
V~ 45 Hz-1 kHz (*45-500Hz)	3.2V 32V 320V 750V	0.001V 0.01V 0.1V 1V	±(3 + 2)* ±(3 + 2) ±(3 + 2) ±(3 + 2)	
V⎓	3.2V 32V 320V 1000V	0.001V 0.01V 0.1V 1V	±(0.7 + 1) ±(0.7 + 1) ±(0.7 + 1) ±(0.8 + 1)	
300mV⎓	320 mV	0.1 mV	±(0.7 + 1)	
Ω	320Ω 3200Ω 32 kΩ 320 kΩ 3.2 MΩ 32 MΩ	0.1Ω 1.0Ω 0.01 kΩ 0.1 kΩ 0.001 MΩ 0.01 MΩ	±(1.0 + 2) ±(1.0 + 1) ±(1.0 + 1) ±(1.0 + 1) ±(1.0 + 1) ±(3 + 1)	
⊳+	2.0V	0.001V	±(1 + 1) v. tipico	
A~ 45 Hz-1 kHz	10A	0.01A	±(3 + 2)	0.5V
A⎓	10A	0.01A	±(2 + 2)	0.5V

FUNZIONE	TENSIONE MAX INGRESSO (tra i morsetti d'ingresso)	TEMPO DI RISPOSTA (dell'indicazione digitale al grado di precisione specificato)	IMPEDENZA D'INGRESSO	RAPPORTO DI REIEZIONE IN MODO COMUNE (1 kΩ sbilancio)	RAPPORTO DI REIEZIONE IN MODO NORMALE (sola indicazione digitale)
V~	1000V CC 750V CA RMS (sinusoidale)	<2s	>10 MΩ in parallelo con <50 pF (accopp. CA)	> 60 dB (CC fino a 60 Hz)	
V⎓	1000V CC 750V CA RMS (sinusoidale)	<1s	>10 MΩ (capacità d'ingresso : <50 pF)	>120 dB (CC, 50 Hz, o 60 Hz)	>60 dB (50 o 60 Hz)
300mV⎓	500V CC 500V CA RMS (sinusoidale)	<1s	10 MΩ (capacità d'ingresso : < 50 pF)	>120 dB (CC, 50 Hz, o 60 Hz)	>60 dB (50 o 60 Hz)

	SOVRACCARICO MAX (tra i morsetti d'ingresso)	TEMPO DI RISPOSTA (dell'indicazione digitale al grado di precisione specificato)	TENSIONE A CIRCUITO APERTO (da 0°C a 50°C)	TENSIONE FONDO SCALE (da 0°C a 50°C)	
				Fino a 3,2 MΩ	Fino a 32 MΩ
Ω	500V CC 500V CA RMS (sinusoidale)	< 1s (fino a 320 kΩ) < 2s (fino a 3,2 MΩ < 10s (fino a 32 MΩ)	< 3,1V CC (v. tipico : < 2,8V CC)	< 440 mV CC (v. tipico : < 420 mV CC)	< 1,4V CC (v. tipico : < 1,3V CC)

TENSIONE MAX TRA QUALUNQUE TERMINALE E LA TERRA (tutte le funzioni) :
1000 V CC 750V CA RMS (sinusoidale)

PROTEZIONE DEI FUSIBILI
15A 600V RAPIDO

	SOVRACCARICO MAX (tra i morsetti d'ingresso)	CORRENTE DI PROVA	
		Corrente di prova (v. tipico)	V_F
⊳+	500V CC 500V CA RMS (sinusoidale)	0.7 mA 0.5 mA 0.3 mA 0.1 mA	0.0V 0.6V 1.2V 2.0V

I valori dei dati tecnici sono specificati con riferimento ad una gamma di temperature compresa tra 18°C e 28°C, per il periodo di un anno dall'avvenuta taratura.

La precisione è specificata come ±([(% valore lettura)] + [(numero di unità nella cifra meno significativa)]).

V~ e A~ hanno risposta a valor medio, calibrato per il valore RMS di onde sinusoidali.

NOTE

This manual documents the Model 8050A and its assemblies at the revision levels shown in Appendix A. If your instrument contains assemblies with different revision letters, it will be necessary for you to either update or backdate this manual. Refer to the supplemental change/errata sheet for newer assemblies, or to the backdating sheet in Appendix A for older assemblies.

8050A

Digital Multimeter

Instruction Manual

P/N 530907
October 1979
REV 1 8/80

FLUKE ®

Table 1-3. 8050A Specifications

ELECTRICAL: The electrical specifications given apply for an operating temperature of 18°C to 28°C (64.4°F to 82.4°F), relative humidity up to 90%, and a 1-year calibration cycle.

FUNCTIONS: DC volts, AC volts (linear and dB), DC current, AC current, resistance, diode test, conductance, relative.

DC VOLTS*:

RANGE	RESOLUTION	ACCURACY for 1-Year
±200 mV	10 μV	
±2V	100 μV	
±20V	1 mV	±(0.03% of reading +2 digits).
±200V	10 mV	
±1000V	100 mV	

INPUT IMPEDANCE: 10 MΩ in parallel with <100 pF, all ranges

NORMAL MODE REJECTION RATIO: >60 dB at 60 Hz or 50 Hz

COMMON MODE REJECTION RATIO: >90 dB at dc, 50 Hz or 60 Hz (1 kΩ unbalanced)
(>120 dB available on request)

COMMON MODE VOLTAGE (MAXIMUM): 500V dc or peak ac

RESPONSE TIME TO RATED ACCURACY: 1 second maximum

MAXIMUM INPUT: 1000V dc or peak ac continuous (less than 10 seconds duration on both the 200 mV and 2V ranges).

*DC Volts can also be measured using the dB mode with .01 dB resolution between 5% of range and full range.

AC VOLTS (TRUE RMS RESPONDING, AC COUPLED):

VOLTAGE READOUT ACCURACY: ± (% of reading + no. of digits), between 5% of range and full range.

INPUT VOLTAGE	RESOLUTION	RANGE	20 Hz** – 45 Hz	45 Hz – 1 kHz	1 kHz – 10 kHz	10 kHz – 20 kHz	20 kHz – 50 kHz	above 50 kHz
10 mV - 200 mV 0.1V - 2V 1V - 20V 10V - 200V	10 μV 100 μV 1 mV 10 mV	200 mV 2V 20V 200V	1%+10	.5%+10	.5%+10	1%+10	5%+30	NOT SPECIFIED
100V - 750V	100 mV	750V			NOT SPECIFIED	NOT SPECIFIED	NOT SPECIFIED	NOT SPECIFIED

***Typically 3 to 5 digits of rattle will be observed at full scale at 20 Hz.*

Table 1-3. 8050A Specifications (cont)

dB RANGES:

<table>
<tr><th rowspan="2">INPUT VOLTAGE</th><th rowspan="2">dBm (600 Ω REF)</th><th colspan="6">ACCURACY: from 5% of range to full scale, 1-year</th></tr>
<tr><th>RANGE</th><th>20 Hz – 45 Hz</th><th>45 Hz – 1kHz</th><th>1kHz – 10 kHz</th><th>10 kHz – 20 kHz</th><th>20 kHz – 50 kHz</th></tr>
<tr><td>0.77 mV - 2 mV</td><td>-60 to -52</td><td>200 mV*</td><td colspan="4">0.5 dBm</td><td>NOT SPECIFIED</td></tr>
<tr><td>2 mV - 2V</td><td>-52 to +8</td><td>200 mV*</td><td rowspan="5">±0.25 dBm</td><td rowspan="5">±0.15 dBm</td><td rowspan="4">±0.15 dBm</td><td rowspan="4">±0.25 dBm</td><td rowspan="4">±0.75 dBm</td></tr>
<tr><td>0.1V - 2V</td><td>-18 to +8</td><td>2V</td></tr>
<tr><td>1V - 20V</td><td>+2 to +28</td><td>20V</td></tr>
<tr><td>10V - 200V</td><td>+22 to +48</td><td>200V</td></tr>
<tr><td>100V - 750V</td><td>+42 to +60</td><td>750V</td><td colspan="3">NOT SPECIFIED</td></tr>
</table>

**When 200 mV range is selected the 8050A autoranges for best accuracy for 2V inputs and less.*

RESOLUTION: 0.01 dB from 5% of scale to full scale; 0.1 dB from 1-5% of scale, 1 dB below 1% of scale.

VOLT - Hz PRODUCT: 10^7 max (200V max @ 50 kHz)

EXTENDED dB RESPONSE: Typically -72 dB (600Ω Ref) ± 1 dB to 10 kHz

EXTENDED FREQUENCY RESPONSE: Typically -3 dB at 200 kHz

COMMON MODE REJECTION RATIO (1 kΩ unbalance): >60 dB at 50 Hz or 60 Hz

CREST FACTOR RANGE: Waveforms with a Peak/RMS ratio of 1:1 to 3:1 at full scale, increasing down range

INPUT IMPEDANCE: 10 MΩ in parallel with <100 pF

MAXIMUM INPUT VOLTAGE: 750V rms or 1000V peak continuous (less than 10 seconds duration on both the 200 mV and 2V ranges), not to exceed the volt-hertz product of 10^7.

RESPONSE TIME: 2 seconds maximum within a range

REFERENCE IMPEDANCES: Fifteen user selectable impedance reference levels are provided to reference a 0 dBm, 1 mW level (50Ω, 75Ω, 93Ω, 110Ω, 125Ω, 135Ω, 150Ω, 250Ω, 300Ω, 500Ω, 600Ω, 800Ω, 900Ω, 1000Ω, 1200Ω), and an 8Ω impedance reference level is provided to reference a 0 dBW level.

DC CURRENT:

<table>
<tr><th>RANGE</th><th>RESOLUTION</th><th>ACCURACY for 1-Year</th><th>BURDEN VOLTAGE</th></tr>
<tr><td>200 μA</td><td>0.01 μA</td><td rowspan="5">±(0.3% of reading + 2 digits</td><td rowspan="4">0.3V max</td></tr>
<tr><td>2 mA</td><td>0.1 μA</td></tr>
<tr><td>20 mA</td><td>1 μA</td></tr>
<tr><td>200 mA</td><td>10 μA</td></tr>
<tr><td>2000 mA</td><td>100 μA</td><td>0.9V max</td></tr>
</table>

OVERLOAD PROTECTION: 2A/250V fuse in series with 3A/600V fuse (for high energy sources).

Table 1-3. 8050A Specifications (cont)

AC CURRENT (TRUE RMS RESPONDING, AC COUPLED):

<table>
<tr><th rowspan="2">INPUT CURRENT</th><th rowspan="2">RESOLUTION</th><th rowspan="2">RANGE</th><th>20 Hz** - 45 Hz</th><th>45 Hz - 2 kHz</th><th>2 kHz - 10 kHz</th><th>10 kHz - 20 kHz</th><th rowspan="2">BURDEN VOLTAGE</th></tr>
<tr><th></th><th></th><th></th><th></th></tr>
<tr><td>10 μA - 200 μA</td><td>0.01 μA</td><td>200 μA</td><td rowspan="5">2%+10</td><td rowspan="5" colspan="1">1%+10</td><td rowspan="4">1%+10</td><td rowspan="4">2%+10</td><td rowspan="4">0.3V rms max</td></tr>
<tr><td>100 μA - 2 mA</td><td>0.1 μA</td><td>2 mA</td></tr>
<tr><td>1 mA - 20 mA</td><td>1 μA</td><td>20 mA</td></tr>
<tr><td>10 mA - 200 mA</td><td>10 μA</td><td>200 mA</td></tr>
<tr><td>100 mA - 2000 mA</td><td>100 μA</td><td>2000 mA</td><td colspan="2">Not specified</td><td>0.9V rms max</td></tr>
</table>

***Typically 3 to 5 digits of rattle will be observed at full scale at 20 Hz.*

CREST FACTOR RANGE: Waveforms with a Peak/RMS ratio of 1:1 to 3:1 at full scale.

RESISTANCE:

RANGE	RESOLUTION	ACCURACY for 1-Year	FULL SCALE VOLTAGE ACROSS UNKNOWN RESISTANCE
200Ω	0.01Ω	±(0.1% reading + 2 digits + .02Ω)	.19V
2 kΩ	0.1Ω		1.2V
20 kΩ	1Ω	±(.05% of reading + 2 digits)	.2V
200 kΩ	10Ω		2V
2000 kΩ	100Ω	±(0.25% reading + 3 digits)	.2V
20 MΩ	1 kΩ		2V

OVERLOAD PROTECTION: 500V dc/ac rms on all ranges

OPEN CIRCUIT VOLTAGE: Less than 3.5V on all ranges

RESPONSE TIME (TO RATED ACCURACY): 10 seconds maximum on 20 MΩ range
2 seconds maximum on all other ranges

DIODE TEST: ➔| These three ranges have enough voltage to turn on silicon junctions to check for proper forward-to-back resistance. The 2 kΩ range is preferred and is marked with a larger diode symbol on the front panel of the instrument. The three non-diode test ranges will not turn on silicon junctions so in-circuit resistance measurements can be made with these three ranges.

CONDUCTANCE:

RANGE	RESOLUTION	ACCURACY for 1-Year
2 mS	.1 μS (10 MΩ)	±(0.1% of reading + 5 digits)
200 nS	.01 nS (100,000 MΩ)	±(0.5% of reading + 20 digits)

MAXIMUM OPEN CIRCUIT VOLTAGE: <3.5V

OVERLOAD PROTECTION: 500V dc/ac rms on all ranges

CONDUCTANCE UNITS: We use the international unit of conductance, the siemen = S = 1/Ω. Another unit of conductance is the mho.

Table 1-3. 8050A Specifications (cont)

RELATIVE:

RELATIVE REFERENCE: An input applied when the RELATIVE button is depressed to the ON position is held as "0" reference point. Subsequent readings indicate the deviation (±) from this point. (Note: REL annunciator indicates when this mode is enabled.)

RELATIVE ACCURACY: Error will not exceed the sum of the errors of the two measurements.

ENVIRONMENTAL:

TEMPERATURE COEFFECIENT: <0.1 times the applicable accuracy specification per °C for 0°C to 18°C and 28°C to 50°C (32°F to 64.4°F and 82.4°F to 122°F).

OPERATING TEMPERATURE: 0°C to 50°C (32°F to 122°F).

STORAGE TEMPERATURE: (without batteries): −40°C to +70°C (−40°F to +158°F).
(with batteries): −40°C to +50°C (−40°F to +122°F).

RELATIVE HUMIDITY: Up to 90%, 0°C to 35°C (32-95°F), up to 70%, 35°C to 50°C (95-122°F), except on 2000 kΩ, 20 MΩ, and 200 nS ranges where it is up to 80%, 0°C to 35°C (32-95°F).

GENERAL:

MAXIMUM COMMON MODE VOLTAGE: 500V dc, or peak ac (low terminal potential with respect to power line ground)

SIZE: 22 cm X 6 cm X 25 cm (8-½" X 2-½" X 10") See Figure 1-8.

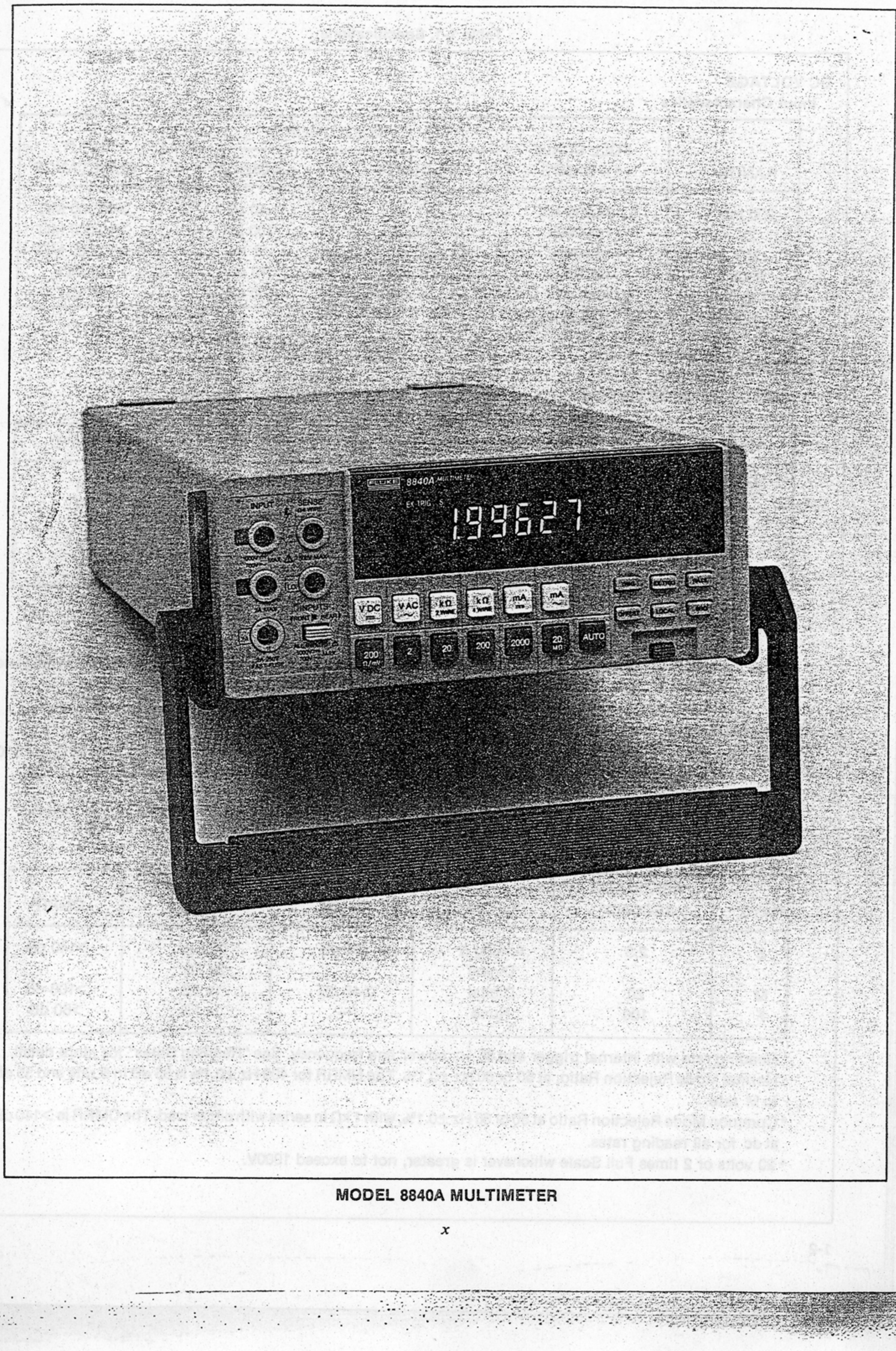
WEIGHT: 1.08 kg (2 lbs., 6 oz.)

POWER REQUIREMENTS (LINE ONLY MODELS):

LINE VOLTAGE: 90 to 110V ac 47 to 440 Hz
105 to 132V ac, 47 to 440 Hz
200 to 264V ac, 47 to 440 Hz
Factory configured for customerspecified voltage.

POWER CONSUMPTION: 4W max.

STANDARDS: IEC 348 Protection Class 1



MODEL 8840A MULTIMETER

Table 1-1. Specifications

DC VOLTAGE

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION 5½ DIGITS	RESOLUTION 4½ DIGITS*	INPUT RESISTANCE
200 mV	199.999 mV	1 μV	10 μV	≥10,000 MΩ
2V	1.99999V	10 μV	100 μV	≥10,000 MΩ
20V	19.9999V	100 μV	1 mV	≥10,000 MΩ
200V	199.999V	1 mV	10 mV	10 MΩ
1000V	1000.00V	10 mV	100 mV	10 MΩ

*4½ digits at the fastest reading rate.

Accuracy

NORMAL (S) READING RATE .... ±(% of Reading + Number of Counts).

RANGE	24 HOUR 23±1°C[1]	90 DAY 23±5°C	1 YEAR 23±5°C
200 mV[2]	0.003 + 3	0.007 + 4	0.008 + 4
2V	0.002 + 2	0.004 + 3	0.005 + 3
20V	0.002 + 2	0.005 + 3	0.006 + 3
200V	0.002 + 2	0.005 + 3	0.006 + 3
1000V	0.003 + 2	0.005 + 3	0.007 + 3

[1] Relative to calibration standards.
[2] Using Offset control.

MEDIUM AND FAST RATES: .... In medium rate, add 2 counts to number of counts. In fast rate, use 2 counts for the number of counts.

Operating Characteristics

TEMPERATURE COEFFICIENT .... <±(0.0006% of Reading + 0.3 Count) per °C from 0°C to 18°C and 28°C to 50°C.

MAXIMUM INPUT .... 1000V dc or peak ac on any range.

NOISE REJECTION .... Automatically optimized at power-up for 50, 60, or 400 Hz.

RATE	READINGS/ SECOND[1]	FILTER	NMRR[2]	PEAK NM SIGNAL	CMRR[3]
S	2.5	Analog & Digital	>98 dB	20V or 2x FS[4]	>140 dB
M	20	Digital	>45 dB	1x FS	>100 dB
F	100	None	—	1x FS	>60 dB

[1] Reading rate with internal trigger and 60 Hz power line frequency. See "Reading Rates" for more detail.
[2] Normal Mode Rejection Ratio, at 50 or 60 Hz ±0.1%. The NMRR for 400 Hz ±0.1% is 85 dB in S rate and 35 dB in M rate.
[3] Common Mode Rejection Ratio at 50 or 60 Hz ±0.1%, with 1 kΩ in series with either lead. The CMRR is >140 dB at dc for all reading rates.
[4] 20 volts or 2 times Full Scale whichever is greater, not to exceed 1000V.

Table 1-1. Specifications (cont)

TRUE RMS AC VOLTAGE (OPTION -09)

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION		INPUT IMPEDANCE
		5½ DIGITS	4½ DIGITS*	
200 mV	199.999 mV	1 µV	10 µV	1 MΩ shunted by <100 pF
2V	1.99999V	10 µV	100 µV	
20V	19.9999V	100 µV	1 mV	
200V	199.999V	1 mV	10 mV	
700V	700.00V	10 mV	100 mV	

*4½ digits at the fastest reading rate.

Accuracy

NORMAL (S) READING RATE .... ±(% of Reading + Number of Counts). For sinewave inputs ≥10,000 counts[1].

FREQUENCY (Hz)	24 HOURS[2] 23±1°C	90 DAY 23±5°C	1 YEAR 23±5°C
20-45	1.2 + 100	1.2 + 100	1.2 + 100
45-100	0.3 + 100	0.35 + 100	0.4 + 100
100-20k	0.07 + 100	0.14 + 100	0.16 + 100
20k-50k	0.15 + 120	0.19 + 150	0.21 + 200
50k-100k	0.4 + 300	0.5 + 300	0.5 + 400

[1] For sinewave inputs between 1,000 and 10,000 counts, add to Number of Counts 100 counts for frequencies 20 Hz to 20 kHz, 200 counts for 20 kHz to 50 kHz, and 500 counts for 50 kHz to 100 kHz.

[2] Relative to calibration standards.

MEDIUM AND FAST READING RATES ... In medium rate, add 50 counts to number of counts. In fast rate the specifications apply for sinewave inputs ≥1000 counts and >100 Hz.

NONSINUSOIDAL INPUTS .... For nonsinusoidal inputs ≥10,000 counts with frequency components ≤100 kHz, add the following % of reading to the accuracy specifications.

FUNDAMENTAL FREQUENCY	CREST FACTOR		
	1.0 TO 1.5	1.5 TO 2.0	2.0 TO 3.0
45 Hz to 20 kHz	0.05	0.15	0.3
20 Hz to 45 Hz and 20 kHz to 50 kHz	0.2	0.7	1.5

Table 1-1. Specifications (cont)

Operating Characteristics

TEMPERATURE COEFFICIENT .... ±(% of Reading + Number of Counts) per °C, 0°C to 18°C and 28°C to 50°C.

FOR INPUTS	FREQUENCY IN HERTZ		
	20-20k	20k-50k	50k-100k
≥10,000 counts ≥1,000 counts	0.019 + 9 0.019 + 12	0.021 + 9 0.021 + 15	0.027 + 10 0.027 + 21

MAXIMUM INPUT .... 700V rms, 1000V peak or 2 x 10^7 Volts-Hertz product (whichever is less) for any range.

COMMON MODE REJECTION .... >60 dB at 50 or 60 Hz with 1 kΩ in either lead.

CURRENT

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION	
		5½ DIGITS	4½ DIGITS*
2000 mA	1999.99 mA	10 μA	100 μA

*4½ digits at the fastest reading rate.

DC Accuracy

NORMAL (S) READING RATE .... ±(% of Reading + Number of Counts).

	90 DAYS 23±5°C	1 YEAR 23±5°C
≤1A >1A	0.04 + 4 0.1 + 4	0.05 + 4 0.1 + 4

MEDIUM AND FAST READING RATES ... In medium reading rate, add 2 counts to number of counts. In fast reading rate, use 2 counts for number of counts.

AC Accuracy (Option -09)

NORMAL (S) READING RATE .... ±(% of Reading + Number of Counts).
1 Year, 23±5°C, for sinewave inputs ≥10,000 counts.

FREQUENCY IN HERTZ		
20-45	45-100	100-5k*
2.0 + 200	0.5 + 200	0.4 + 200

*Typically 20 kHz

Table 1-1. Specifications (cont)

MEDIUM AND FAST READING RATES ... In medium rate, add 50 counts to number of counts. In fast reading rate, for sinewave inputs ⩾1000 counts and frequencies >100 Hz, the accuracy is ±(0.4% of reading + 30 counts).

NONSINUSOIDAL INPUTS .... For nonsinusoidal inputs ⩾10,000 counts with frequency components ⩽100 kHz, add the following % of reading to the accuracy specifications.

FUNDAMENTAL FREQUENCY	CREST FACTOR		
	1.0 TO 1.5	1.5 TO 2.0	2.0 TO 3.0
45 Hz to 5 kHz	0.05	0.15	0.3
20 Hz to 45 Hz	0.2	0.7	1.5

Operating Characteristics

TEMPERATURE COEFFICIENT .... Less than 0.1 x accuracy specification per °C from 0°C to 18°C and 28°C to 50°C.

MAXIMUM INPUT .... 2A dc or rms ac. Protected with 2A, 250V fuse accessible at front panel, and internal 3A, 600V fuse.

BURDEN VOLTAGE .... 1V dc or rms ac typical at full scale.

RESISTANCE

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION		CURRENT THROUGH UNKNOWN
		5½ DIGITS	4½ DIGITS*	
200Ω	199.999Ω	1 mΩ	10 mΩ	1 mA
2 kΩ	1.99999 kΩ	10 mΩ	100 mΩ	1 mA
20 kΩ	19.9999 kΩ	100 mΩ	1Ω	100 μA
200 kΩ	199.999 kΩ	1Ω	10Ω	10 μA
2000 kΩ	1999.99 kΩ	10Ω	100Ω	5 μA
20 MΩ	19.9999 MΩ	100Ω	1 kΩ	0.5 μA

*4½ digits at the fastest reading rate.

Accuracy

NORMAL (S) READING RATE .... ±(% of Reading + Number of Counts)[1]

RANGE	24 HOUR 23±1°C[2]	90 DAY 23±5°C	1 YEAR 23±5°C
200Ω	0.004 + 3	0.011 + 4	0.014 + 4
2 kΩ	0.0028 + 2	0.01 + 3	0.013 + 3
20 kΩ	0.0028 + 2	0.01 + 3	0.013 + 3
200 kΩ	0.0028 + 2	0.01 + 3	0.013 + 3
2000 kΩ	0.023 + 3	0.027 + 3	0.028 + 3
20 MΩ	0.023 + 3	0.043 + 4	0.044 + 4

[1] Using Offset control.
[2] Relative to calibration standards.

Table 1-1. Specifications (cont)

Accuracy, cont

MEDIUM AND FAST READING RATES ... In medium rate, add 2 counts to the number of counts for the 200Ω through 200 kΩ ranges and 3 counts for the 2000 kΩ and 20 MΩ ranges. In fast reading rate, use 3 counts for the number of counts for the 200Ω range, and 2 counts for all other ranges.

Operating Characteristics

TEMPERATURE COEFFICIENT .... Less than 0.1 x accuracy specification per °C from 0°C to 18°C and 28°C to 50°C.

MEASUREMENT CONFIGURATION ...... 2-wire or 4-wire.

OPEN CIRCUIT VOLTAGE .... Less than 6.5V on the 200Ω through 200 kΩ ranges. Less than 13V on the 2000 kΩ and 20 MΩ ranges.

INPUT PROTECTION .... To 300V rms.

READING RATES

READING RATES WITH INTERNAL TRIGGER .... (readings per second).

RATE	POWER LINE FREQUENCY*		
	50 HZ	60 HZ	400 HZ
S	2.08	2.5	2.38
M	16.7	20	19.0
F	100	100	100

*Sensed automatically at power-up.

AUTOMATIC SETTLING TIME DELAY

Time in milliseconds from single trigger to start of A/D conversion, Autorange off.

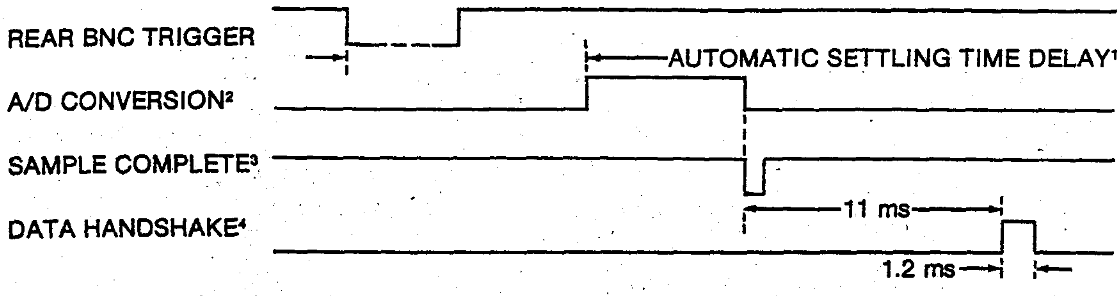
FUNCTION	RANGE	READING RATE			NUMBER OF COUNTS FROM FINAL VALUE[1]
		S	M	F	
VDC	200 mV	342	61	9	5
	2V-1000V	342	17	9	9
VAC	All	551	551	551	30 (Note 2)
mA DC	2000 mA	342	17	9	5
mA AC	2000 mA	551	551	551	30 (Note 2)
Ohms	200Ω	362	89	13	5
	2 kΩ	322	17	13	5
	20 kΩ	342	17	13	5
	200 kΩ	141	121	21	5
	2000 kΩ	141	101	81	10
	20 MΩ	1020	964	723	10

1. Difference between first reading and final value for an in-range step change coincident with trigger.
2. For slow reading rate. 50 counts for medium rate; 10 counts for fast rate.

Table 1-1. Specifications (cont)

EXTERNAL TRIGGER TIMING CHARACTERISTICS

The following diagram shows the nominal timing for the various processes which take place between an external trigger and data sent out on the IEEE-488 interface. Delays will vary if a second trigger comes before the data handshake is complete.



NOTES:

1. Time from single trigger to start of A/D conversion. (See "Automatic Settling Time Delay" on previous page.) If the delay is disabled by using the T3 or T4 command, then the delay is 1 ms ±150 μs. When the 8840A is triggered with an IEEE-488 command (GET or ?), the automatic settling time delay begins after the trigger command has been processed and recognized.

2. A/D conversion time is dependent on the reading rate and power-line frequency:

RATE	A/D CONVERSION TIME (ms)		
	50 Hz	60 Hz	400 Hz
S	472	395	414
M	52	45	47
F	7	7	7

3. Sample Complete is a 2.5 μs pulse which indicates that the analog input may be changed for the next reading.

4. When talking to a fast controller.

GENERAL

COMMON MODE VOLTAGE	1000V dc or peak ac, or 700V rms ac from any input to earth.
TEMPERATURE RANGE	0 to 50°C operating, -40 to 70°C storage.
HUMIDITY RANGE	80% RH from 0 to 35°C, 70% to 50°C.
WARMUP TIME	1 hour to rated specifications.
POWER	100, 120, 220, or 240V ac ±10% (250V ac maximum), switch selectable at rear panel. 50, 60, or 400 Hz, automatically sensed at power-up. 20 VA maximum.
VIBRATION	Meets requirements of MIL-T-28800C for Type III, Class 3, Style E equipment.
PROTECTION	ANSI C39.5 and IEC 348, Class I.
SIZE	8.9 cm high, 21.6 cm wide, 37.1 cm deep (3.47 in high, 8.5 in wide, 14.4 in deep).
WEIGHT	Net, 3.4 kg (7.5 lb); shipping, 5.0 kg (11 lb).
INCLUDED	Line cord, test leads, Instruction/Service Manual, IEEE-488 Quick Reference Guide, (Option -05 only), and instrument performance record.
IEEE-488 INTERFACE FUNCTION	Option allows complete control and data output capability, and supports the following interface function subsets: SH1, AH1, T5, L4, SR1, RL1, DC1, DT1, E1, PP0, and C0.

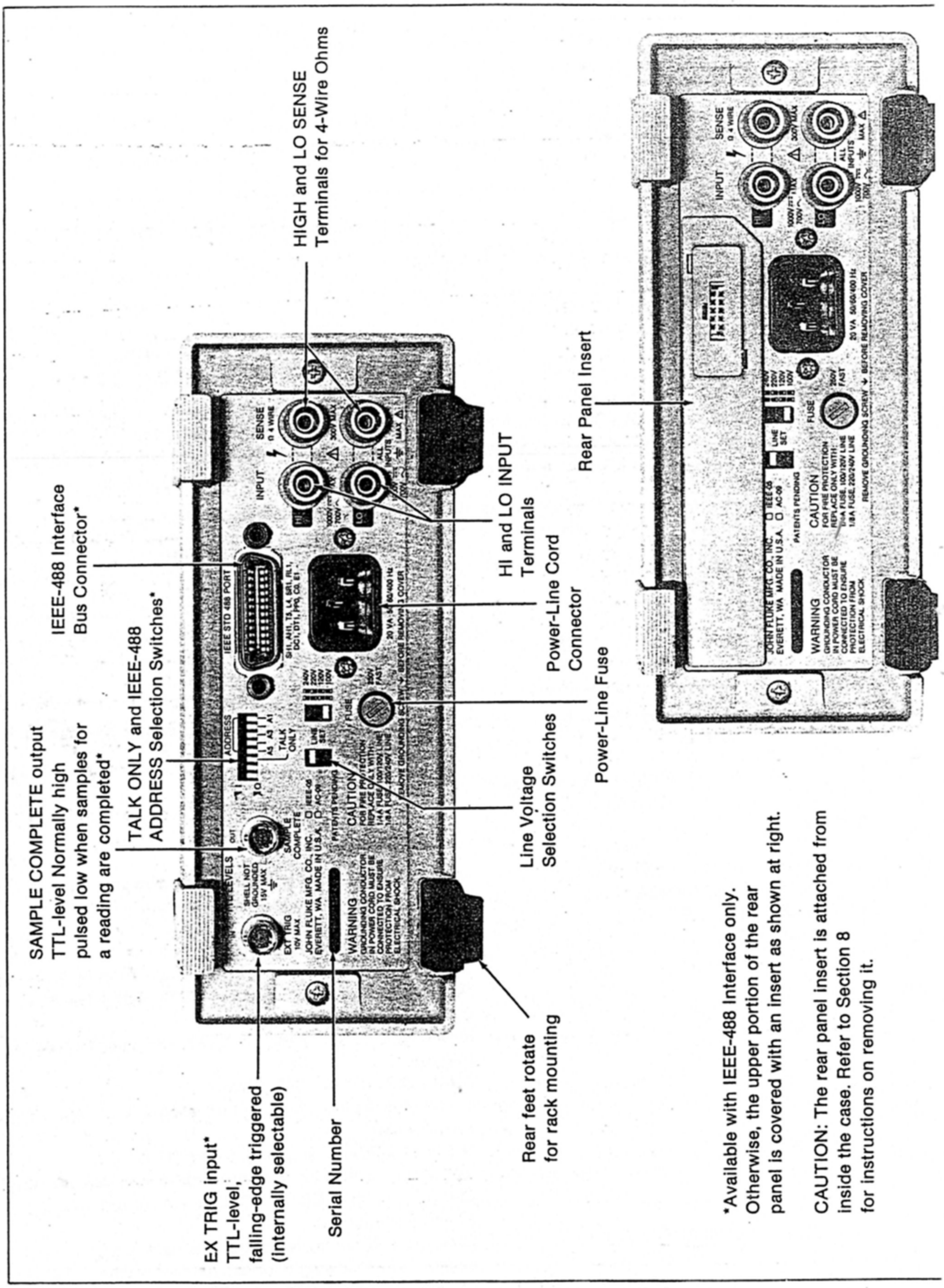
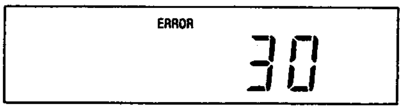
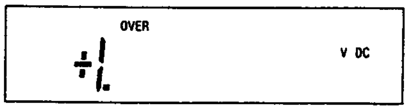


Figure 2-6. Rear Panel Features



Error 30: AC function selected without True RMS AC Converter option.

Figure 2-7. Typical Error Message



OVER: Input ≥2V dc in 2V range.

Figure 2-8. Overrange Indication

Table 2-1. Error Codes

ERROR CODE	MEANING
	ANALOG SELF-TEST ERRORS
1	200 VAC, Zero
2	700 VAC, Zero
3	mA AC, Zero
4	mA DC, Zero
5	200 VDC, Zero
6	1000 VDC, Zero
7	1000 VDC + 20 MΩ
8	20 VDC + 20 MΩ
9	20 VDC + 2000 kΩ
10	2 VDC + 2000 kΩ
11	200Ω, Overrange
12	2 kΩ, Overrange
13	20 kΩ, Overrange
14	200 kΩ, Overrange
15	1000 VDC + X10 T/H + 20 MΩ
16	200 VDC + 200 kΩ
17	200 VDC + 20 kΩ
18	200 VDC + 2 kΩ
19	200 VDC, Filter On
20	200 VDC + 2 kΩ, Filter Off
21	200 VDC, Filter Off
	DIGITAL SELF-TEST ERRORS
25	In-Guard uC Internal RAM
26	Display RAM
27	In-Guard uC Internal Program Memory
28	External Program Memory
29	Calibration Memory
	OPERATION ERRORS
30	AC functions available only with True RMS AC option.
31	mA AC or mA DC function selected while REAR inputs selected.
32	OFFSET selected with reading unavailable or overrange.

ERROR CODE	MEANING
40	Computed calibration constant out of range. (Previous cal may be wrong or there may be a hardware problem.)
41	Calibration input out of acceptable range. Check that input is correct. (Previous cal may be wrong or there may be a hardware problem.)
42	Calibration memory write error. (Probably a hardware problem.)
50	Guard crossing error detected by In-Guard uC.
51	Calibration command not valid unless calibration mode is enabled.
52	Command not valid at this time. Check whether 8840A is in cal mode and if so which part of the cal procedure it is in.
53	Invalid calibration value in Put command. (Example: Sending a negative value during ac calibration.)
54	Command not valid in calibration verification.
56	Variable inputs not allowed during A/D calibration. Use prompted value.
60	Device-dependent commands not valid during self-tests.
71	Syntax error in device-dependent command string.
72	Guard crossing error detected by Out-Guard uC.
77	IEEE-488 Interface self-test error.

NOTE: See the Maintenance section for a detailed description of self-tests.

SPECIFICATIONS

FUNCTION	DM-311		
	RANGE	RESOLUTION	ACCURACY
DC VOLTAGE	200 mV 2 V 20 V 200 V 1000 V	0.1 mV 1 mV 10 mV 100 mV 1 V	±(0.5%+1dgt)
AC VOLTAGE	200 mV 2 V 20 V 200 V 750 V	0.1 mV 1 mV 10 mV 100 mV 1 V	±(0.75%+3dgt)
DC CURRENT	200μA 2mA 20mA 200mA	0.1μA 1μA 10μA 100μA	±(1.0%+2dgt)
	10 A	10mA	±(1.5%+2dgt)

* *Accuracy is ginven as ±(% of reading + number of least sgnificant digits) at 18℃ to 28℃ with relative humidity up to 80% for a period of one year after calibraton.*
* *Sources like small hand-held radio transceivers, fixed station radio and television transmitters, vehicle radio transmitters and cellular phones generate electromagnetic radiation that may induce voltages in the test leads of the multimeter. In such cases the accuracy of the multimeter cannot be guaranteed due to physical reasor*

SPECIFICATIONS

FUNCTION	DM-311		
	RANGE	RESOLUTION	ACCURACY
AC CURRENT	200μA 2mA 20mA 200mA	0.1μA 1μA 10μA 100μA	±(2.0%+2dgt)
	10 A	10mA	±(3.0%+2dgt)
RESISTANCE	200 Ω	0.1 Ω	±(0.5%+4dgt)
	2 KΩ 20 KΩ 200 KΩ 2 MΩ	1 Ω 10 Ω 100 Ω 1 KΩ	±(0.5%+1dgt)
	20 MΩ	10 KΩ	±(1.0%+1dgt)
CAPACITANCE	-	-	-

* *Accuracy is ginven as ±(% of reading + number of least sgnificant digits) at 18℃ to 28℃ with relative humidity up to 80% for a period of one year after calibraton.*
* *Sources like small hand-held radio transceivers, fixed station radio and television transmitters, vehicle radio transmitters and cellular phones generate electromagnetic radiation that may induce voltages in the test leads of the multimeter. In such cases the accuracy of the multimeter cannot be guaranteed due to physical reas*

Each of AC/DC voltage ranges presents an input impedance of approximately 10 MΩ in parallel with less than 50 pF. AC voltage is AC-Coupled to the 10 MΩ input, and frequency range is 50Hz to 400Hz

SPECIFICATIONS

DC VOLTAGE

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

Temperature Coefficient (0°-18° and 28°-55°C): ±(0.006% + 0.2 digit)/°C
Input Resistance: 10MΩ ±0.1%
Settling Time: 1 second to within 1 digit of final reading.

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.

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
2 V	1.9999	0.4% + 15d	0.04% + 0.5d	0.09% + 0.5d
20 V	19.999	0.3% + 15d	0.01% + 0.5d	0.03% + 0.5d
200 V	199.99	0.3% + 15d	0.01% + 0.5d	0.03% + 0.5d
1000 V	1000.0	0.3% + 15d	0.01% + 0.5d	0.03% + 0.5d

Extended Frequency Accuracy:
(45Hz-100Hz) ±(0.5% + 15 digits)
(10kHz-20kHz) ±(1.0% + 15 digits)
Response: Average responding calibrated in rms of a sinewave.
Settling Time: 2.5 seconds to within 10 digits of final reading.

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.

RESISTANCE

RANGE	MAXIMUM READING	ACCURACY (12 months) 18°-28°C ±(% rdg + digits)	TEMPERATURE COEFFICIENT 0°-18° and 28°-55°C ±(% rdg + digits)/°C	NOMINAL APPLIED CURRENT
2 kΩ	1.9999	0.04% + 2d	0.003% + 0.2d	1mA
20 kΩ	19.999	0.04% + 1d	0.003% + 0.2d	100μ A
200 kΩ	199.99	0.04% + 1d	0.003% + 0.2d	10μ A
2000 kΩ	1999.9	0.04% + 1d	0.003% + 0.2d	1μ A
20MΩ	19.999	0.10% + 1d	0.02 % + 0.2d	0.1μ A

Maximum Allowable Input: 250V rms sine, 350V peak.
Maximum Voltage Across Unknown: 2V within range, 5V open circuit.

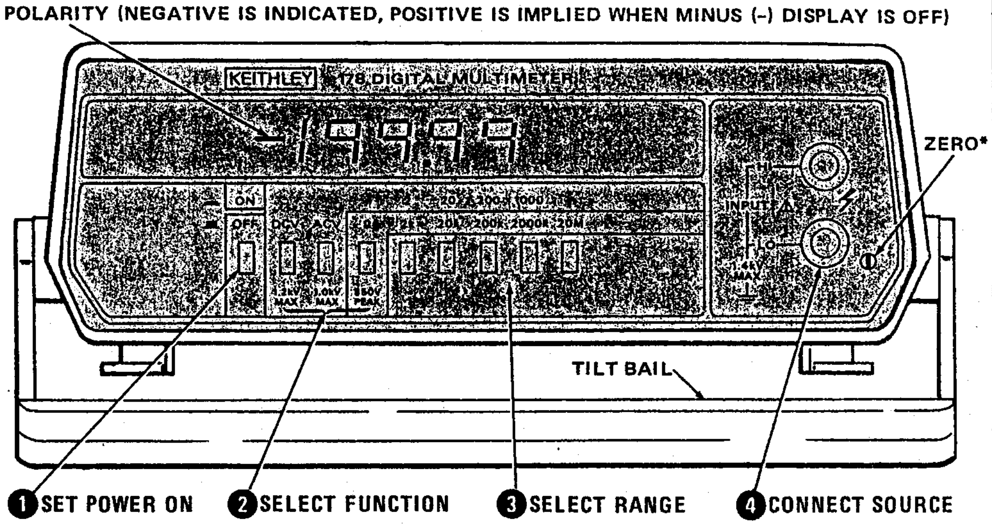
Settling Time: 1 second to within 1 digit of final reading except 2 seconds on the 20MΩ range.

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 (3lbs., 13 oz).
OVERRANGE INDICATION: Display blinks all zeros above 19999 counts.
MAXIMUM COMMON MODE VOLTAGE: 1400V peak.

OPERATING INSTRUCTIONS



* NOTE: See zero control on second page of Operating Instructions.

(1) TO OPERATE FROM LINE POWER:

- Set the Line Switch as described in INITIAL PREPARATION.
- Connect the power cord to line power.
- Set power to ON.

TO OPERATE FROM BATTERY POWER:

- Install the Model 1788 as described in INITIAL PREPARATION.
- Charge the Model 1788.
- Disconnect the power cord.
- Set power to ON.

(2) FUNCTION AND RANGE SELECTION: The pushbuttons are interlocked to avoid improper settings.

(3) **DCV and ACV:** Four ranges are available. The maximum reading is 19999. Overrange is indicated by a flashing 0000 except on the 1000 volts range. Care should be taken not to exceed the maximum ratings. On **DCV**, polarity is displayed automatically and a positive display is implied when the minus display is off.

Ω(OHMS): Five ranges are available. The maximum reading is 19999. Overrange is indicated by a flashing 0000. Care should be taken not to exceed the maximum ratings. The engineering units refer to kilohms (k) or megohms (M).

The **HI** terminal is positive and causes forward conduction of semiconductor junctions. Two volts is applied at full range with 5 volts under open circuit conditions.

(4) INPUT CONNECTIONS: Use the Model 1681, 1683 or other appropriate banana jack test leads.

KEITHLEY DMM 199

SPECIFICATIONS

DC VOLTS (5½ Digits)

RANGE	RESOLUTION	INPUT RESISTANCE	ACCURACY[1] ±(%rdg + counts) 24 Hours[2] 23°±1°C	90 Days 18°-28°C	1 Year 18°-28°C
300 mV	1 µV	>1 GΩ	0.004 + 3[3]	0.009 + 3[3]	0.012 + 3[3]
3 V	10 µV	>1 GΩ	0.003 + 2	0.006 + 2	0.007 + 2
30 V	100 µV	11 MΩ	0.004 + 2	0.008 + 2	0.009 + 2
300 V	1 mV	10 MΩ	0.004 + 2	0.008 + 2	0.009 + 2

[1]For 4½-digit accuracy, count error is 5 (except 15 on 300mV range).
[2]Relative to calibration standards.
[3]When properly zeroed.

CMRR: >120dB at dc, 50Hz or 60Hz (±0.05%) with 1kΩ in either lead.

NMRR: >60dB at 50Hz or 60Hz (±0.05%).

MAXIMUM ALLOWABLE INPUT: 300V rms or 425V peak, whichever is less.

TRMS AC VOLTS (5½ Digits)

RANGE	RESOLUTION	ACCURACY[1] ±(%rdg + counts) 1 Year, 18°-28°C: 20 Hz - 50 Hz[2]	50 Hz - 200 Hz[2]	200 Hz - 20 kHz[2]	20 kHz - 100 kHz[3]
300 mV	1 µV	2 + 100	0.35 + 100	0.15 + 200	2.0 + 300
3 V	10 µV	2 + 100	0.35 + 100	0.15 + 200	1.5 + 300
30 V	100 µV	2 + 100	0.35 + 100	0.15 + 200	1.5 + 300
300 V	1 mV	2 + 100	0.35 + 100	0.15 + 200	1.5 + 300

[1]For 4½-digit accuracy, divide count error by 10; 4½-digit specifications apply for inputs >200Hz.
[2]Sinewave inputs >2000 counts.
[3]Sinewave inputs >20,000 counts.

RESPONSE: True root mean square, ac coupled.

CREST FACTOR (ratio of peak to rms): Up to 3:1 allowable.

NON-SINUSOIDAL INPUTS (>20,000 counts):
For rectified sine wave, add 0.3% of reading to above specifications for fundamental frequencies <20kHz.
For pulse waveforms, add 0.3% of reading for fundamental frequencies <1kHz, or 3.5% for frequencies <10kHz.

INPUT IMPEDANCE: 1MΩ shunted by <100pF.

MAXIMUM ALLOWABLE INPUT: 300V rms or 425V peak, 10^7V•Hz, whichever is less.

CMRR: >60dB at 50Hz or 60Hz (±0.05%) with 1kΩ in either lead.

SETTLING TIME: 1 second to within 0.1% of change in reading.

dB (ref = 1V):

INPUT	RESOLUTION	ACCURACY ±dB 1 Year, 18°-28°C: 20 Hz-20 kHz	20 kHz-100 kHz
−34 to +49 dB (20 mV to 300 V)	0.01 dB	0.2	0.4
−54 to −34 dB (2 mV to 20 mV)	0.01 dB	1.1	—

OHMS (5½ Digits)

RANGE	RESOLUTION	NOMINAL I-SHORT	ACCURACY[1] ±(%rdg + counts) 24 Hours[4] 23° ±1°C	90 Days 18°-28°C	1 Year 18°-28°C
300 Ω[2]	1 mΩ	1.7 mA	0.005 + 4[3]	0.009 + 4[3]	0.012 + 4[3]
3 kΩ[2]	10 mΩ	1.7 mA	0.004 + 2	0.008 + 3	0.009 + 3
30 kΩ[2]	100 mΩ	160 µA	0.004 + 2	0.008 + 3	0.009 + 3
300 kΩ	1 Ω	50 µA	0.014 + 2	0.024 + 3	0.026 + 3
3 MΩ	10 Ω	5 µA	0.02 + 2	0.03 + 3	0.03 + 3
30 MΩ	100 Ω	0.5 µA	0.1 + 5	0.12 + 5	0.12 + 5
300 MΩ	1 kΩ	0.5 µA	2.0 + 5	2.0 + 5	2.0 + 5

[1]For 4½-digit accuracy, count error is 5 (except 15 on 300Ω range).
[2]4-wire accuracy, 300Ω-30kΩ ranges.
[3]When properly zeroed.
[4]Relative to calibration standards.

CONFIGURATION: Automatic 2- or 4-wire.

MAXIMUM ALLOWABLE INPUT: 300V rms or 425V peak, whichever is less.

OPEN CIRCUIT VOLTAGE: <5.5V.

DC AMPS (5½ Digits)

RANGE	RESOLUTION	ACCURACY[1] ±(%rdg + counts) 1 Year, 18°-28°C	MAXIMUM VOLTAGE BURDEN
30 mA	100 nA	0.05 + 15	0.4 V
3 A	10 µA	0.1 + 15	2 V

[1]For 4½-digit accuracy, count error is 20.

MAXIMUM ALLOWABLE INPUT: 3A. Protected with 3A, 250V fuse accessible from front panel.

TRMS AC AMPS (5½ Digits)

RANGE	RESOLUTION	ACCURACY[1] ±(%rdg + counts) 1 Year, 18°-28°C: 20 Hz-45 Hz	45 Hz-10 kHz	MAXIMUM VOLTAGE BURDEN
30 mA	100 nA	2 + 100	0.6 + 100	0.4 V
3 A	10 µA	2 + 100	0.6 + 100	2 V

[1]Inputs >2000 counts. For 4½-digit accuracy, divide count error by 10; 4½-digit specifications apply for inputs >200Hz.

RESPONSE: True root mean square, ac coupled.

CREST FACTOR (ratio of peak to rms): Up to 3:1 allowable at ⅔ full range.

NON-SINUSOIDAL INPUTS: Specified accuracy for fundamental frequencies <1kHz.

MAXIMUM ALLOWABLE INPUT: 3A. Protected with 3A, 250V fuse accessible from front panel.

SETTLING TIME: 1 second to within 0.1% of final reading.

dB (ref = 1mA):

INPUT	RESOLUTION	ACCURACY ±dB 1 Year, 18°-28°C 20 Hz-10 kHz
−14 to +69 dB (200 µA to 3 A)	0.01 dB	0.6

199 Front Panel Operation

TRIG SETUP

SHIFT/TRIG SETUP to enter menu.

NEXT to scroll to next menu option.

Trigger	▲/▼	CONTINUOUS: Reading, scanning, and storing rates controlled by INTERVAL.
		ONE SHOT.
DELAY		0sec to 999.999sec
INTERVAL	▲/▼	SELECT OFF: Interval ≥175msec, depending on other programmed parameters.
		SELECT ON: User-programmed interval (15msec to 999.999sec).

DMM SETUP

SHIFT/DMM SETUP to enter menu.

NEXT to scroll to next menu option.

REV		Displays current software revision level.
MUX	▲/▼	MUX OFF: Turns off autocal routines for faster reading rates.
		MUX ON: Recommended for best accuracy.
IEEE		Use numeric keys to program IEEE-488 primary address (0-30).
FREQ	▲/▼	FREQ=50HZ. Line frequency.
		FREQ=60HZ. Line frequency.
SAVE	▲/▼	SAVE YES: Saves present configuration.
		SAVE NO
LEDS	▲/▼	LEDS ON: Test front panel LEDs and annunciators.
		LEDS OFF
DEBUG	▲/▼	DEBUG YES: Enter troubleshooting mode.
		DEBUG NO
RESET	▲/▼	RESET YES: Returns unit to factory default configuration.
		RESET NO

ONE-SHOT OPERATION

In the one-shot trigger mode, each reading consists of multiple conversions to fill the Running Average User Filter (30 conversions), or the Running Average Internal Filter (5½d only, varies by ranges and function– see manual). For this reason, trigger-to-reading time could be several seconds, depending on filtering. When filters are off ("P0" command over the bus can be SAVEd), readings are made up of only one conversion.

STORE

- SHIFT/STORE to enter data store.
- SIZE = 1 to 500, or SIZE = 000 for wrap around.
- NEXT to exit size select.
- TRIGGER to initiate storage.
- Any function key to cancel storage.
- RCL flashes when data store is full.

RECALL

- SHIFT/RECALL to enter recall.
- NEXT to view data at displayed location.
- ▲ or ▼ to scroll through locations.
- RECALL again to select desired location.
- NEXT to display data.
- NEXT to exit recall mode.

ERROR MESSAGES

UNCAL	EEPROM failure on power up
OVERFL	Overrange
TRIGGER OVERRUN	Unit triggered while processing reading.
INTERVAL OVERRUN	Interval too short for selected configuration.
AC ONLY	dB selected with unit not in ACV or ACA.
NO RANGE	Pressing range button in dB.
CAL LOCKED	Calibration locked out when calibrating.
CONFLICT	Unit in invalid state when calibrating (i.e., autorange).
NO DATA	Entering recall with no data stored.
NO SCANNER	Scanner not installed.

TYPICAL 5½ DIGIT CONVERSION TIMES

MUX ON, DCV, ACV, ACA: 110msec (133msec)
MUX OFF: 28msec (33msec)

MUX ON, OHMS, 300kΩ range and lower: 110msec (133msec)
MUX OFF: 63msec (78msec)
(Times in parenthesis are for 50Hz operation)

TYPICAL AUTORANGING TIMES

DCV, DCA	350msec
ACV, ACA	1.4sec
OHMS (300kΩ range and lower)	500msec

(Times shown are to correct range and do not include conversion times for final reading.)

LCR meter

Dimension	:	185 x 87 x 39mm (7.3 x 3.4 x 1.5 inch).
Weight	:	322 g/0.71 lb (including battery).
Standard Accessories	:	Test alligator clips (red & black) . . . . 1 pair.
		Instruction manual . . . . 1pc.

2-2 ELECTRICAL SPECIFICATION

A. Inductance & Capacitance

L (Inductance)			
Range	Resolution	Test Frequency	Current through Inductance under test
2mH	1uH	1KHZ	150uA
20mH	10uH	1KHZ	150uA
200mH	100uH	1KHZ	150uA
2H	1mH	1KHZ	150uA
20H	10mH	100HZ	15 uA

uH = micro Henry (10^{-6} H). mH = mili Henry (10^{-3} H)

C (Capacitance)			
Range	Resolution	Test Frequency	Voltage across Capacitance under test
2nF	1pF	1KHZ	150mV
20nF	10pF	1KHZ	150mV
200nF	100pF	1KHZ	150mV
2uF	1nF	1KHZ	150mV
20uF	10nF	100HZ	150mV
200uF	100nF	100HZ	15mV

pF = pico Farad (10^{-12} F), nF = nan Farad (10^{-9} F).
uF = micro Farad (10^{-6} F).

Accuracy (23°C ± 2°C):

Capacitance: ≤ – ± (1.5 % + 1d) – 2nF range
– ± (1% + 1d) – Others
> 0.5uF – ± (2% + 1d)

Inductance: ≤ 0.5H – ± (2% + 1d)
> 0.5H – ± (5% + 1d)

Temperature coefficient:

Capacitance: ≤ 0.5uF – 0.1%/°C
> 0.5uF – 0.2%/°C

Inductance: ≤ 0.5H – 0.2%/°C
> 0.5H – 0.5%/°C

Zero Error:

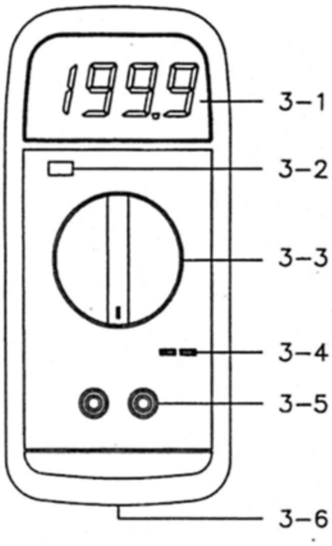
Capacitance – 2nF range, < 5pF.
Inductance – < 10uH.

Overload Rating: Charged capacitor, 100 μF capacitance max., 50V charged voltage max....

B. Resistance range

RANGE	ACCURACY	RESOLUTION	OPEN CIRCUIT VOLTAGE
200Ω	± (1% + 3d)	0.1Ω	Approx DC 1.2V
2KΩ	± (0.8% + 1d)	1Ω	
20KΩ		10Ω	Approx. DC 250 mV
200KΩ		100Ω	
2000KΩ		1KΩ	
20MΩ	± (2% + 2d)	10KΩ	

3. FRONT PANEL DESCRIPTION



3-1 Display
3-2 LC/R select switch
3-3 Function/Power off switch
3-4 Measuring input terminal 1
3-5 Measuring input terminal 2
3-6 Battery compartment/Cover

4. CONSIDERATION OF MEASUREMENT

(1) This LCR METER is intended for measuring the capacitance value of a capacitor, the inductance value of an inductor. It is not intended for determining the "Q" factor for above reactive components. Misleading readings may be obtained if the measurement of the inductance or capacitance of a resistor is attempted.

(2) When measuring components within circuit that circuit must be switched off and de-energized before connecting the test leads.

(3) Instruments used in dusty environments should be stripped and cleaned periodically.

(4) Do not leave the instrument exposed to direct heat from the sun for long periods.

(5) Before removing the battery compartment cover, ensure that the instrument is disconnected from any circuit and the power switch is in the off position.

(6) For all measurements, should connect BLACK test lead into "–" terminal and RED test lead into "+" terminal.

5. INDUCTANCE (L) MEASUREMENT PROCEDURE

(1) Slide the LC/R(3-2, Fig. 1) select switch to the "LC" position.

(2) Rotate the function switch for the maximum expected inductance range.

(3) Insert the tested inductor into socket of the "Measuring input terminal 1"
Or Connect the alligator clips (from "Measuring input terminal 2") to the tested inductor leads.

(4) Read the display. The value is direct reading in the electrical units (mH, H) indicated at the selected switch. If DISPLAY show "1", it indicate on Out-of-Range measurement. If the display indicates one of more reading zeros, shift to the next lower range scale to improve the resolution of the measurement.

NOTE:

(a) If the inductance value is unmarked, start with the 2mH range and keep increasing until the over-range indication goes off and a reading is obtained.
(b) Measure of very low inductance should be performed using extremly short leads in order to avoid introducing any stray inductance.
(c) This instruments is not intended for determining the "Q" factor for the inductor. Misleading readings may be obtained if the measurement of the inductance of a resistor is attempted.

6. CAPACITANCE (C) MEASURING PROCEDURE

(1) Slide the LC/R(3-2, Fig. 1) select switch to the "LC" position.
(2) Rotate the function switch for the maximum expected capacitance range.
(3) Observe polarity when connecting polarized capacitors.
(4) Full discharge any capacitors.
(5) Insert the tested capacitor into socket of the "Measuring input terminal 1".
Or Connect the alligator clips (from "Measuring input terminal 2") to the tested capacitor leads.
(6) Read the display. The value is direct reading in the electrical units (pF, nF, uF) indicated at the selected range switch. If DISPLAY show "1", It indicate on Out-of-Range measurement. If the display indicates one or more leading zeros, shift to the next lower range scale to improve the resolution of the measurement.

NOTE:

(a) If the capacitance value is unmarked, start with the 2nF range and keep increasing until the over-range indication goes off and a reading is obtained.
(b) A capacitor with low voltage leakage with read over range, or a much higher value than normal.
An open capacitor will read zero on all ranges (possibly a few pF on 2nF range, due to stray capacitance of the instrument).
(c) Measure of very low capacitance should be performed using extremly short leads in order to avoid introducing any stray capacitance.
(c) When using the optioned test leads, remember that the leads introduce a measurable capacitance to the measurement. As a first approximation, the test lead capacitance may be measured by opening the leads at the trips, recording the open circuit value and subtracting that value.
(e) Capacitors, especially electrolytics, often have notoriously wide tolerances. Do not be suprised if the measured value is greater than the value marked on the capacitor, unless it is a close tolerance type. However, values are seldom drastically below the rated value.

7. RESISTANCE (R) MEASURING PROCEDURE

(1) Slide the LC/R(3-2, Fig. 1) select switch to the "R" position.
(2) Rotate the function switch for the maximum expected resistance range.
(3) Insert the test resistor into socket of the "Measuring input terminal 1"
Or Connect the alligator clips (from "Measuring input terminal 2") to the tested resistor leads.

(4) Read the display. The value is direct reading in the electrical units (Ω, K Ω, MΩ) indicated at the selected function range switch. If DISPLAY show "1". It indicate on Out-of-Range measure ment.
If the display indicates one or more leading zeros. shift to the next lower range scale to improve the resolution of measurement.

NOTE:

If need to make precise measurement (especial on 200 ohm range), at first please short the test lead, then record the display values. After making measurement, please deduct above stray resistance values, will get the true measurement values.

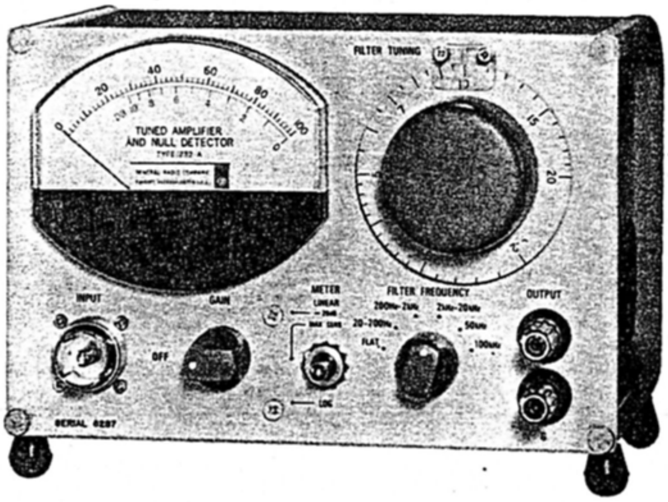
8. BATTERY REPLACEMENT

(1) When the left corner of LCD display show "BAT", it indicate a normal battery output of less than 6.5V – 7.5V. It is necessary to replace the battery. However, in-spec measurement may still be made for several hours after LOW BATTERY INDICATOR appears before the instrument become inaccurate.
(2) Slide the battery cover (3-6) Fig. 1, away from the instrument and remove the battery.
(3) Replace with 9V battery and reinstall the cover.
(4) Please must use the "HEAVY DUTY" type battery.

9107-120318-905

Type 1232-A TUNED AMPLIFIER AND NULL DETECTOR

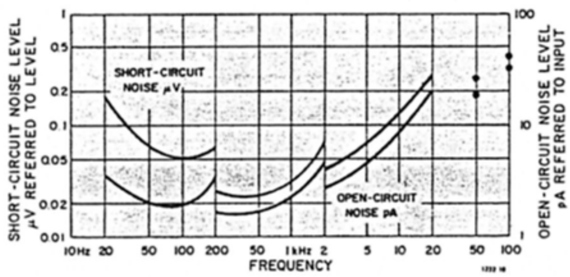
- 20 Hz to 20 kHz, 50 and 100 kHz
- 0.1-μV sensitivity
- bandwidth approx 5%
- 120-dB gain



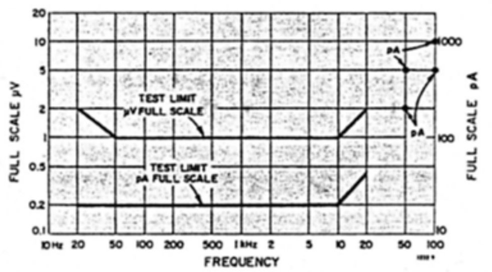
This battery-operated, solid-state amplifier will excel in common applications and fit many unusual requirements with its combined high sensitivity, low noise, choice of narrow or broad bandwidth, high gain, portability, and accessories for added versatility. Use it as a

- bridge detector at audio frequencies; with the 1232-P2 Preamplifier it is equally sensitive for extremely high-impedance, low-frequency balances. With the 1232-P1 RF Mixer it is a sensitive, heterodyne, rf detector to 10 MHz with excellent harmonic rejection.
- audio preamplifier and general-purpose, tunable or broadband audio amplifier
- a-m detector for 0.5- to 500-MHz carrier frequencies when used with an 874-VQ Voltmeter Detector;
- sensitive audio wave analyzer for approximate measurements.

— See **GR Experimenter** for July 1961.



(Left) Typical noise levels as a function of frequency. (Right) Minimum input for full-scale meter deflection as a function of frequency, when amplifier is tuned to peak response.



specifications

Frequency Response:
Tunable Filters — 20 Hz to 20 kHz in 3 ranges; between 2% and 6% bandwidth to 15 kHz; 2nd harmonic at least 34 dB down from peak, 3rd at least 40 dB down; rejection filter on two highest ranges reduces 60-Hz level to at least 60 dB below peak (50 dB at 50 Hz). Dial accuracy is ±3%.
50- and 100-kHz Filters — 2nd harmonic 44 and 53 dB down, respectively.
Flat Response — ±3 dB 20 Hz to 100 kHz.
Sensitivity: See plot. Typically better than 0.1 μV over most of the frequency range.

Noise Level Referred to Input: See plot. Noise figure at 1 kHz is less than 2 dB at an optimum source impedance of 27 kΩ.

Noise Level Referred to Output: Less than 5 mV on FLAT filter-frequency position, min gain setting, and −20-dB switch position; less than 50 mV in MAX SENS position.

Input Impedance: Approx 50 kΩ at max gain; varies inversely with gain to 1 MΩ at min gain.
Max Safe Input Voltage: 200 V ac or 400 V dc.

Voltage Gain: Approx 120 dB on the tunable ranges; 100 dB, flat range; 106 dB at 50 kHz; 100 dB at 100-kHz position.
Output: 1 V into 10,000 Ω. Internal impedance is 3000 Ω.

Meter Linearity: DB differences are accurate to ±5% ±0.1 division for input of less than 0.3 V.

Compression (on LOG position): Reduces full-scale sensitivity by 40 dB. Does not affect bottom 20% of scale.
20-dB Position: Reduces gain by 20 dB in linear mode.

Distortion (in FLAT position): Less than 5% (from meter rectifiers).
Power Supply: 12 V dc, from 9 mercury (M72) cells in series. Est battery life 1500 hours. Optionally, a rechargeable battery (non-mercury) can be supplied on special order.
Accessories Available: 1232-P1 RF Mixer for heterodyne operation to 10 MHz; 1232-P2 Preamplifier to maintain sensitivity of 1232-A at low frequencies when operating from a source impedance above 100 kΩ; rack-adaptor sets (see below) convert 1232 and companion instruments to 19-in. rack-mount width.
Terminals: Input, GR874 coaxial connector; output, binding posts.
Mounting: Convertible-Bench Cabinet.
Dimensions (width x height x depth): 8 x 6 x 7½ in. (205 x 155 x 190 mm).
Weight: Net, 5¾ lb (2.7 kg); shipping, 8 lb (3.7 kg).

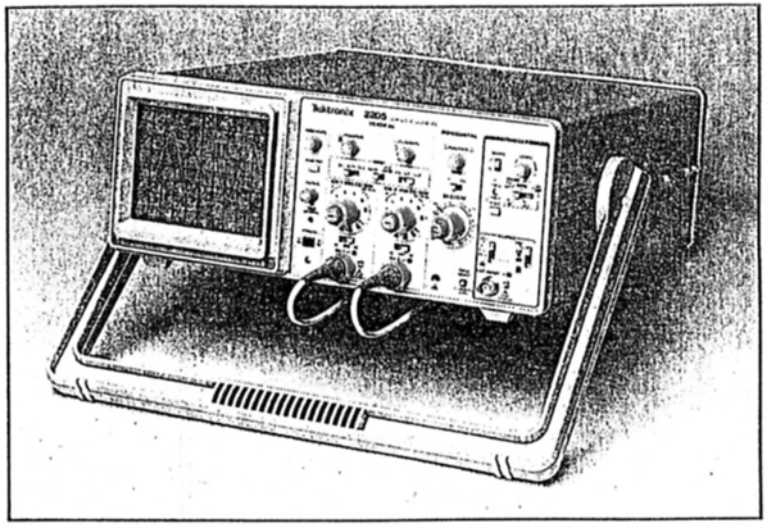
Catalog Number	Description
1232-9701	**1232-A Tuned Amplifier and Null Detector**
1232-9829	**1232-AP Tuned Amplifier and Null Detector,** with preamplifier
	Rack-Adaptor Sets
0480-9838	**480-P308,** for 1232-A alone
0480-9836	**480-P316,** for 1232-A with 1310 or 1311 oscillator or similar 8-in. wide instrument with convertible-bench cabinet
0480-9837	**480-P317,** for 1232-AP (with preamp) and companion 8-in. instrument
8410-1372	**Replacement Battery,** 9 req'd

PATENT NOTICE. See Note 15.

TEK

OPERATOR'S MANUAL
070-6717-00

2205 OSCILLOSCOPE



Tektronix®
COMMITTED TO EXCELLENCE

The 2205 electrical characteristics listed in Table 5–1 are valid when it has been adjusted at an ambient temperature between +20°C and +30°C, has had a warm–up period of at least 20 minutes, and is operating at an ambient temperature between 0°C and +40°C (unless otherwise noted).

Environmental characteristics are given in Table 5–2. The 2205 meets the requirements of MIL–T–28800C, paragraphs 4.5.5.5.1.3, 4.5.5.1.4, and 4.5.5.1.2.2 for Type III, Class 5 equipment, except where otherwise noted.

Mechanical characteristics of the instrument are listed in Table 5–3.

TABLE 5–1
Electrical Characteristics

Characteristics	Performance Requirements
VERTICAL DEFLECTION SYSTEM	
Deflection Factor	
Range	5 mV per division to 5 V per division in a 1–2–5 sequence of 9 steps.
Accuracy	± 3%.
Variable Control Range	Continuously variable and uncalibrated between step settings. Increases deflection factor by at least 2.5 to 1.
Step Response (Rise Time)	Applicable from 5 mV per division to 5 V per division. Rise times calculated from: $t_r = \frac{0.35}{BW}$
+5°C to +35°C	17.5 ns or less.
0°C to +5°C and +35°C to +40°C	23.3 ns or less.

TABLE 5-1 (cont'd)

Characteristics	Performance Requirements	
HORIZONTAL DEFLECTION SYSTEM		
Sweep Rate		
Calibrated Range	0.5 s per division to 0.1 μs per division in a 1-2-5 sequence. Magnification extends maximum usable sweep speed to 10 ns per division.	
Accuracy	Magnified	
	X1	X10
+15 °C to +35 °C	± 3%	± 4%
0 °C to +40 °C	± 4%	± 5%
Variable Control Range	Continuously variable and uncalibrated between calibrated step settings. Decreases calibrated sweep speeds at least by a factor of 2.5.	
Sweep Linearity	Magnified	
	X1	X10
	± 5%	± 7%
Position Control Range	Start of sweep, to 10th division in X1 and to 100th division in X10, will position past the center vertical graticule line.	
Registration of Unmagnified and Magnified Traces	0.2 division or less, aligned to central vertical graticule line.	

TABLE 5-1 (cont'd)

Characteristics	Performance Requirements
Z-MODULATION	
Sensitivity	5 V causes noticeable modulation. Positive-going input decreases intensity.
Usable Frequency Range	Dc to 5 MHz.
Maximum Safe Input Voltage	400 V (dc + peak ac) or 800 V ac p-p to 10 kHz or less.
X-Y OPERATION (X1 MODE)	
Deflection Factors	Same as Vertical Deflection System with Variable controls in CAL detents.
Accuracy	
X-Axis	± 5%
Y-Axis	Same as Vertical Deflection System.
Bandwidth (-3 dB)	
X-Axis	Dc to at least 1 MHz.
Y-Axis	Same as Vertical Deflection System.
Phase Difference Between X- and Y-Axis Amplifiers	± 3° from dc to 50 kHz.
PROBE ADJUSTMENT SIGNAL OUTPUT	
Voltage into 1 MΩ Load	0.5 V ± 5%.
Repetition Rate	1 kHz ± 20%.

TABLE 5-1 (cont'd)

Characteristics	Performance Requirements
VERTICAL DEFLECTION SYSTEM (cont'd)	
Bandwidth (−3 dB)	
+5°C to +35°C	20 MHz or more.
0°C to +5°C and +35°C to +40°C	15 MHz or more.
AC Coupled Lower Cutoff Frequency	10 Hz or less at −3 dB.
CHOP Mode Switching Rate	500 kHz ± 30%.
Input Characteristics	
Resistance	1 MΩ ± 2%.
Capacitance	25 pF ± 2 pF.
Maximum Safe Input Voltage (DC or AC Coupled)	400 V (dc + peak ac) or 800 V ac p-p to 10 kHz or less.
Common-Mode Rejection Ratio (CMRR)	At least 10 to 1 at 20 MHz.
Trace Shift	
With VOLTS/DIV Switch Rotation	0.75 division or less (Variable control in CAL detent).
With VOLTS/DIV Variable Control Rotation	1.0 division or less.
With Channel 2 Inverted	1.5 divisions or less.
Channel Isolation	Greater than 100 to 1 at 10 MHz.

TABLE 5-1 (cont'd)

Characteristics	Performance Requirements	
TRIGGER SYSTEM		
Trigger Sensitivity		
P-P AUTO/TV LINE and NORM Modes	5 MHz	30 MHz
Internal Signal	0.3 div	1.0 div
External Signal	40 mV	150 mV
Lowest Usable Frequency in P-P AUTO Mode	≥20 Hz	
TV FIELD Mode	1.0 division of composite sync.	
External Input		
Resistance	1 MΩ ± 10%.	
Capacitance	25 pF ± 2.5 pF.	
Maximum Voltage	400 V (dc + peak ac) or 800 V ac p-p at 10 kHz or less.	
Trigger Level Range		
NORM Mode	±15 divisions referred to the appropriate vertical input.	
EXT Source	At least ±1.6 V, 3.2 V p-p.	
EXT/10 Source	At least ±16 V, 32 V p-p.	

TABLE 5-1 (cont'd)

Characteristics	Performance Requirements
POWER REQUIREMENTS	
Line Voltage Ranges	
115 V Setting	95 V ac to 128 V ac.
230 V Setting	185 V ac to 250 V ac.
Line Frequency	48 Hz to 440 Hz.
Maximum Power Consumption	40 W (60 VA).
Line Fuse	UL198.6, 3AG (1/4 x 1 1/4 inch)
115 V Setting	0.75 A Slow
230 V Setting	0.5 A, Slow
CATHODE-RAY TUBE	
Display Area	80 by 100 mm.
Standard Phosphor	GH (P31).
Nominal Accelerating Voltage	1800 V ±10%.

Table 5-2
Environmental Characteristics

Characteristics	Performance Requirements
Temperature	
Operating	0°C to +40 °C (+32°F to +104 °F).
Nonoperating	-55 °C to +75 ° (-67 °F to +167 °F).
Altitude	
Operating	To 4500 m (15,000 ft.). Maximum operating temperature decreases 1° C per 300 m (1,000 ft.) above 1,500 m (5,000 ft.).
Nonoperating	To 15,250 m (50,000 ft.).
Relative Humidity	
Operating (+30°C to +40 °C)	85% +0%, -5%
Nonoperating (+30°C to +60 °C)	85% +0%, -5%
Vibration (Operating)	15 minutes along each of three major axes at a total displacement of 0.015 inch p-p (2.4 g at 55 Hz) with frequency varied from 10 Hz to 55 Hz to 10 Hz in one-minute sweeps. Hold for 10 minutes at 55 Hz in each of three major axes. All major resonances must be above 55 Hz.
Shock (Operating and Nonoperating)	30 g, half-sine, 11-ms duration, three shocks per axis each direction, for a total of 18 shocks.
Radiated and Conducted Emission Requirements	Meets VDE 0871 Class B.

Table 5-3
Mechanical Characteristics

Characteristics	Performance Requirements
Weight With Power Cord	8.25 kg (13.7 lbs) or less.
Domestic Shipping Weight	9.1 kg (20.0 lbs) or less.
Height	138 mm (5.4 in).
Width	
With Handle	379 mm (14.9 in).
Without Handle	327 mm (12.9 in).
Depth	
Without Front Cover	441 mm (17.4 in).
With Optional Front Cover	455 mm (17.9 in).
With Handle Extended	516 mm (20.3 in).

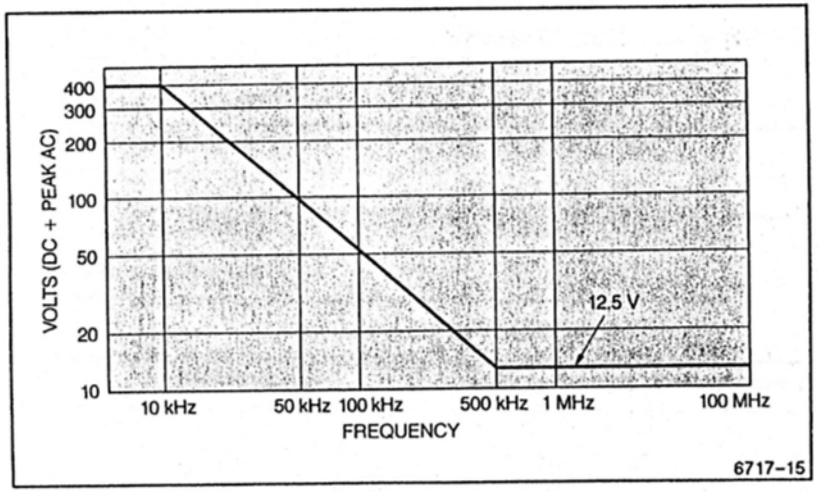


Figure 5-1. Maximum input voltage versus frequency derating curve for CH 1 OR X, CH 2 OR Y, and EXT INPUT connectors.

SPECIFICATIONS

FREQUENCY

Measurement Range	476 µHz to 100 kHz, baseband and zoomed.
Spans	191 mHz to 100 kHz in a binary sequence.
Center Frequency	Anywhere within the measurement range subject to span and range limits.
Accuracy	25 ppm from 20°C to 40°C.
Resolution	Span/400
Window Functions	Blackman-Harris, Hanning, Flattop and Uniform.
Real-time Bandwidth	100 kHz

SIGNAL INPUT

Number of Channels	1
Input	Single-ended or true differential
Input Impedance	1 MΩ, 15 pf
Coupling	AC or DC
CMRR	90 dB at 1 kHz (Input Range < -6 dBV) 80 dB at 1 kHz (Input Range <14 dBV) 50 dB at 1 kHz (Input Range ≥ 14 dBV)
Noise	5 nVrms/√Hz at 1 kHz typical, 10 nVrms/√Hz max. (-166 dBVrms/√Hz typ., -160 dBVrms/√Hz max.)

AMPLITUDE

Full Scale Input Range	-60 dBV (1.0 mVpk) to +34 dBV (50 Vpk) in 2 dB steps.
Dynamic Range	90 dB typical
Harmonic Distortion	No greater than -90 dB from DC to 50 kHz. (Input Range ≤ 0 dBV) No greater than -80 dB to 100 kHz.
Spurious	Input range ≥ -50 dBV: No greater than -85 dB below full scale below 200 Hz. No greater than -90 dB below full scale to 100 kHz.
Input Sampling	16 bit A/D at 256 kHz
Accuracy	± 0.2 dB ± 0.003% of full scale (excluding windowing effects).
Averaging	RMS, Vector and Peak Hold. Linear and exponential averaging up to 64k scans.

TRIGGER INPUT

Modes	Continuous, internal, external, or external TTL.
Internal	Level: Adjustable to ±100% of input scale. Positive or Negative slope. Minimum Trigger Amplitude: 10% of input range.
External	Level: ±5V in 40 mV steps. Positive or Negative slope. Impedance: 10 kΩ Minimum Trigger Amplitude: 100 mV.
External TTL	Requires TTL level to trigger (low<.7V, high>2V).
Post-Trigger	Measurement record is delayed by 1 to 65,000 samples (1/512 to 127 time records) after the trigger. Delay resolution is 1 sample (1/512 of a record).
Pre-Trigger	Measurement record starts up to 51.953 ms prior to the trigger. Delay resolution is 3.9062 µs.
Phase Indeterminacy	<2°

DISPLAY FUNCTIONS	
Display	Real, imaginary, magnitude or phase spectrum.
Measurements	Spectrum, power spectral density, time record and 1/3 octave.
Analysis	Band, sideband and total harmonic distortion.
Trace Math	Add, subtract, multiply, and divide with a constant, ω (2πf), or another trace. Log (base 10), square root, phase unwrap and d/dx functions.
Graphic Expand	Display expands up to 50x about any point in the display.
MARKER FUNCTIONS	
Harmonic Marker	Displays up to 400 harmonics of the fundamental.
Delta Marker	Reads amplitude and frequency relative to defined reference.
Next Peak/Harmonic	Locates nearest peak or harmonic to the left or right.
Data Tables	Lists Y values of up to 200 user defined X points.
Limit Tables	Automatically detects data exceeding up to 100 user defined upper and lower limit trace segments.

SOURCE OUTPUT			
Amplitude Range	0.1 mVpk to 1.000 Vpk		
Amplitude Resolution	1 mVpk (Output>100 mVpk); 0.1 mVpk (Output ≤ 100.0 mVpk)		
DC Offset	<10.0 mV (typical)		
Output Impedance	< 5 Ω; ±50 mA peak output current.		
SINE			
Amplitude Accuracy	±1% (0.09 dB) of setting, 0 Hz to 100 kHz, 0.1 Vpk to 1.0 Vpk, high impedance load.		
Frequency Resolution	15.26 mHz (1 kHz/65536)		
Harmonics, Sub-Harmonics,	0.1 Vpk to 1 Vpk	0 to 10 kHz	<-80 dBc
		10 kHz to 100 kHz	<-70 dBc
Spurious Signals	<-100 dBV (typical, line frequency related)		
TWO TONE			
Amplitude Accuracy	±1% (0.09 dB) of setting, 0 Hz to 100 kHz, 0.1 Vpk to 0.5 Vpk, high impedance load.		
Frequency Resolution	15.26 mHz (1 kHz/65536)		
Harmonics, Sub-Harmonics	0.1 Vpk to 0.5 Vpk	0 to 10 kHz	<-80 dB below larger tone
		10 kHz to 100 kHz	<-70 dB below larger tone
Spurious Signals	<-100 dBV (typical, line frequency related)		
WHITE NOISE	Output is 0 Hz to 100 kHz at all measurement spans.		
Flatness	<0.25 dB pk-pk (typical), <1.0 dB pk-pk (max) (5000 rms averaged spectra, Source Cal on).		
PINK NOISE	Output is 0 Hz to 100 kHz at all measurement spans.		
Flatness	<4.0 dB pk-pk, 20 Hz - 20 kHz (measured using 1/3 octave analysis, Source Cal on).		
CHIRP	Output is equal amplitude sine waves at each frequency bin of the measurement span.		
Flatness	Measured spectra (all spans, Source Cal on) <0.05 dB pk-pk (typical), <0.2 dB pk-pk (max), Amplitude=1.0 Vpk.		
Phase	Auto Phase function calibrates to current phase spectrum.		

TEST CERTIFICATE

Date of issue	10th November,1982.	*Certificate Nº*	5385/V
Item	Standard Cell		
Type Nº	1268	*Serial Nº*	241588
Tested for	BELOTTI, ITALY:		

The ambient temperature throughout the test was 20°C. ± 1°C.

The temperature coefficient of the cell at 20°C. is:

-40ppm/°C.

The cell was compared with Laboratory Standards traceable to N.P.L.

VALUE AT 20.0°C. 1.018625 VOLTS

UNCERTAINTY OF MEASUREMENT = ± 10 p.p.m.

H.T.C. 3

Tested by: [signature]

H. Tinsley & Co. Ltd.
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