BOONTON ELECTRONICS CORPORATION

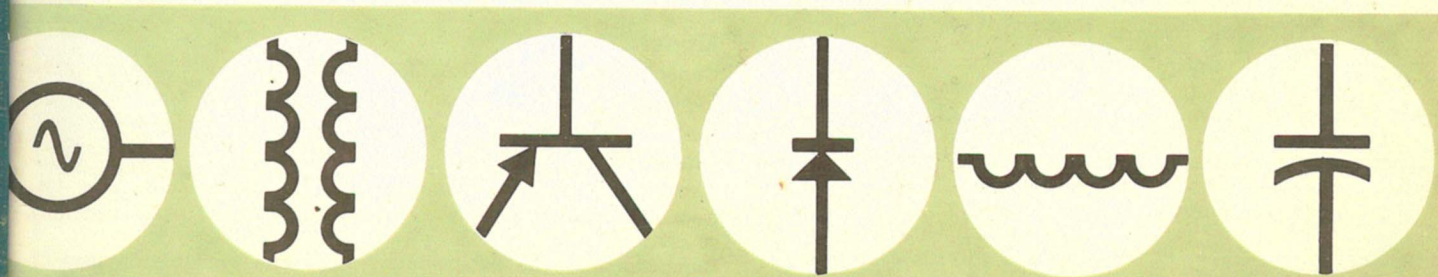
Route 287 at Smith Rd.,
Parsippany, N. J. 07054
TEL: 201-887-5110
TWX: 710-986-8241

Instruments & Accessories

Abridged Catalog IC-15

March 1971

For measurement of



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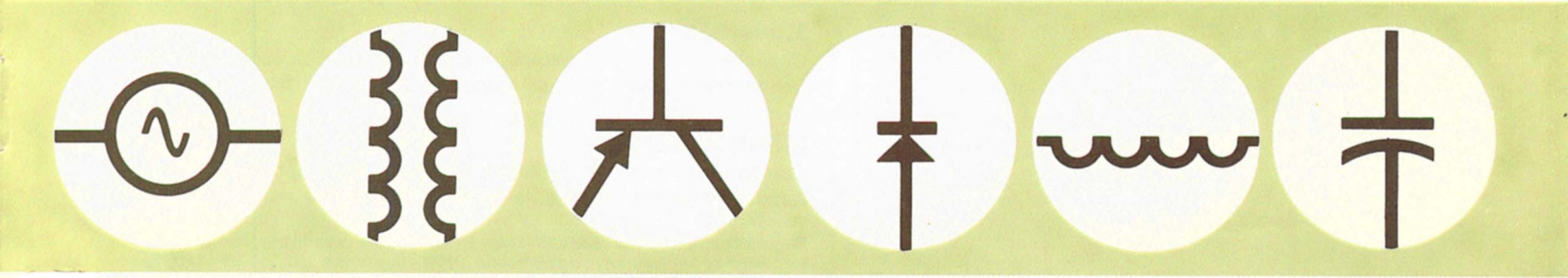
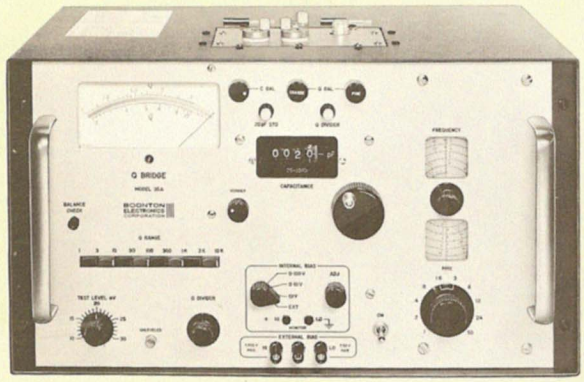


E P I L M k C G y h C G R Q L R Q D C G D Q

Q Bridge

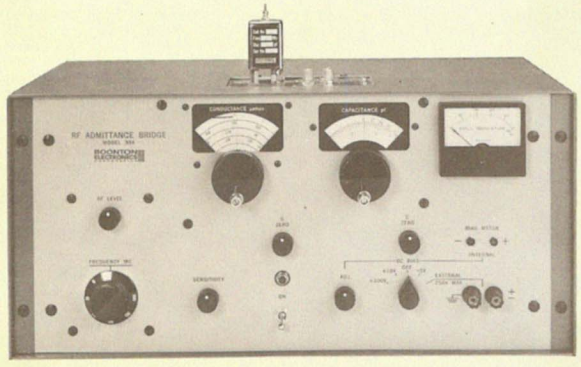


Model 35A Q Bridge

This revolutionary, non-resonant, three-terminal bridge measures capacitance and its Q directly over a wide frequency range to Q values as high as 10,000. The low test signal level may be set by a calibrated front panel control, and complete facilities for dc biasing the test component are provided. Measurements of a variety of capacitors and solid state devices such as high Q varactors, diodes, ceramic and monolithic capacitors are now possible. The Model 35A is also a unique new tool for studying the frequency characteristics of many other components and materials.

Q: 5 to 10,000; accuracy, generally ± 10% to ± 30%.
Capacitance: 2 to 1000 pF; accuracy, generally ± 0.5% to ± 2%.
Test Signal: Frequency, 100 kHz to 50 MHz; level, 10-30 mV rms.
Range Extensions: 0.002 to 2 pF; 1000 pF to 0.25 μF.
Indirect Measurements: Inductance; rf resistance.

RF Admittance Bridges



RF Admittance Bridges

These bridges measure two-terminal parallel capacitance and conductance from 1 to 100 MHz. Seven crystal-controlled test frequencies of 1, 5, 10, 20, 30, 50, and 100 MHz are supplied as standard on all versions. Other frequencies between 1 and 100 MHz can be provided to special order. Good resolution of low conductance values makes loss measurements possible on many high Q diodes, varactors, and capacitors. The bridge balances accurately with the low test levels required for measurements on most solid state devices. Internal and external dc bias is standard on all models. (For accessories see pages 11 and 12.)

Model 33A/1

Capacitance: 0-150 pF (30 pF at 100 MHz); resolution, 0.02 pF; basic accuracy, ± 0.3%.
Conductance: 0-25 mmhos; resolution, 0.5 μmho; basic accuracy, ± 2%.

Model 33B/1

Capacitance: 0-150 pF (30 pF at 100 MHz); resolution, 0.02 pF; basic accuracy, ± 0.3%.
Conductance: 0-5 mmhos; resolution, 0.1 μmho; basic accuracy, ± 2%.

Model 33C/1

Capacitance: 0-15 pF; resolution, 0.002 pF; basic accuracy, ± 1%.
Conductance: 0-25 mmhos; resolution, 0.5 μmho; basic accuracy, ± 2%.

Model 33D/1

Capacitance: 0-15 pF; resolution, 0.002 pF; basic accuracy, ± 1%.
Conductance: 0-5 mmhos; resolution, 0.1 μmho; basic accuracy, ± 2%.
Capacitance Range Extensions: Accessories available for measuring higher values of capacitance at frequencies up to 30 MHz for Model 33A/1 and to 20 MHz for Model 33B/1. (See page 12.)

Capacitance/Inductance Meters

Capacitance/Inductance Meter — 1 MHz
Model 71A

Quick, convenient, direct reading, 3-terminal measurements of capacitance and 2-terminal measurements of inductance. Internally supplied 1 MHz test signal. Operates with low test signal level, permitting semiconductor tests. Linear meter scales. Provision for dc bias. Linear dc output proportional to capacitance or inductance reading for display on dvm, x-y plotter, for data logging or, with suitable voltage comparator, for go/no-go testing. (For accessories see pages 10 and 11.)

Capacitance: 1 pF to 1000 pF fs in 7 ranges; basic accuracy, ± 0.5% rdg ± 0.5% fs; resolution, 0.25% fs.

Inductance: 1 μH to 1 mH fs in 7 ranges; basic accuracy, ± 0.5% rdg ± 0.5% fs; resolution, 0.25% fs.

Test Signal: Frequency 1 MHz; level, 15 mV rms for capacitance measurements, < 1 mV for inductance measurements.

Q: Specified accuracies apply for test specimens having Q's of 3 or more; lower with readjustment.

DC Bias: Externally supplied up to ± 200 V.

DC Analog Output: 0 to 100 mV or 300 mV fs depending on range numerics; also > 1 V fs for loads > 10 M Ω; linearity, 0.1% of reading; response time, 10 ms; 1 ms to special order.

Capacitance/Inductance Meter — 100 kHz
Model 71CR

Quick, convenient, direct reading, 3-terminal measurements of capacitance or 2-terminal measurements of inductance. Internally supplied 100 kHz test signal. Operates with low test signal level, permitting semiconductor tests. Linear meter scales. Provision for dc bias. Linear dc output proportional to capacitance or inductance reading for display on dvm, x-y plotter, for data logging or, with suitable voltage comparator, for go/no-go testing. (For accessories see pages 10 and 11.)

Capacitance: 10 pF to .01 μF fs in 7 ranges; basic accuracy, ± 0.5% rdg ± 0.5% fs; resolution, 0.25% fs.

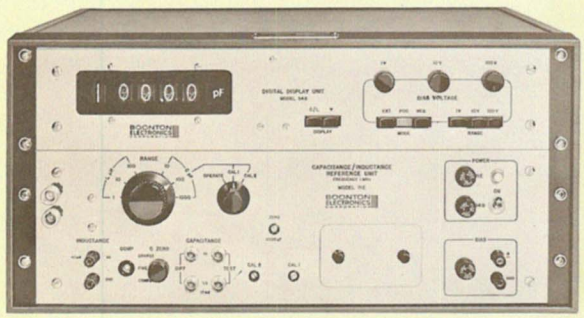
Inductance: 10 μH to 10 mH fs in 7 ranges; basic accuracy ± 0.5% rdg ± 0.5% fs; resolution, 0.25% fs.

Test Signal: Frequency, 100 kHz; level, 15 mV rms for capacitance measurements, < 1 mV for inductance measurements.

Q: Specified accuracies apply for test specimens having Q's of 3 or more; lower with readjustment.

DC Bias: Externally supplied up to ± 200 V.

DC Analog Output: 0 to 100 mV or 300 mV fs depending on range numerics; also > 1 V fs for loads > 10 M Ω; linearity, 0.1% of reading; response time, 20 ms.



Digital Capacitance/Inductance Meter
Model 700C

Direct-reading 3-terminal measurements of capacitance and 2-terminal measurements of inductance are made substantially independent of the loss of the test sample. The 4-1/2 digit Nixie-type readout has a display period of 200 ms and 40% overrange. BCD outputs are provided for printer or computer interface. The highly stabilized internal dc bias supply allows three independently settable voltages to be selected as required. This feature, in conjunction with the low 15 mV rms test level and the true 3-terminal input makes the 700C ideal for measurements on many semiconductor devices. An internal 100 pF standard is provided to maintain the best accuracy at all times. (For accessories see pages 10 and 11.)

Capacitance: 10, 100, and 1000 pF fs (+ 40% overrange); basic accuracy, ± 0.25% rdg ± 0.05% fs.

Inductance: 1, 10, and 100 μH fs (+ 40% overrange); basic accuracy, ± 0.5% rdg ± 0.5% fs.

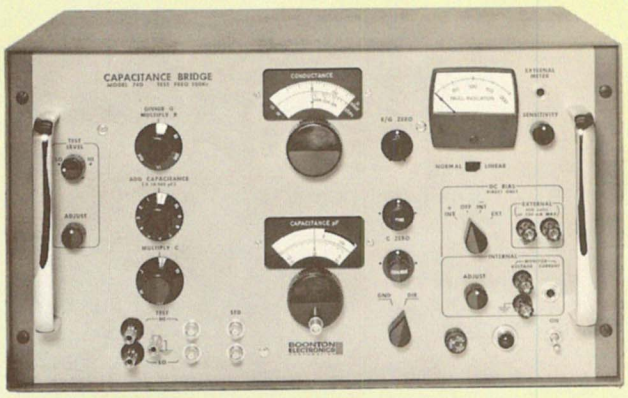
Test Signal: Frequency, 1 MHz; level, 15 mV rms for capacitance measurements, < 1 mV for inductance.

Readout: 4-1/2 digit; TTL compatible BCD outputs; display period, 200 ms; integration time, 1/15 s.

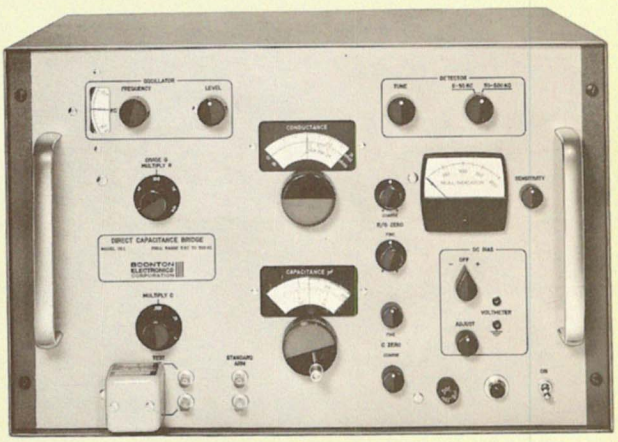
DC Bias: Internal, 0 to ± 1.4 V; 0 to ± 14 V; 0 to ± 140 V. Regulation, 0.05%, 10 mA max. External, ± 200 V. Bias voltage monitored on digital readout; accuracy, ± 0.1% rdg ± 2 counts.

Capacitance Bridges

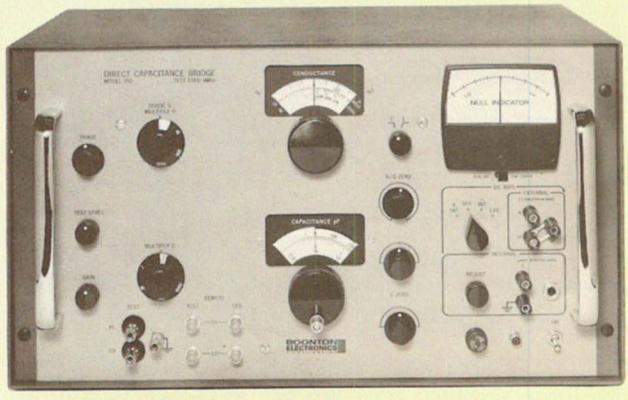
Capacitance Bridge — 100 kHz
Model 74D



Capacitance Bridge — 5 kHz to 500 kHz
Model 75C



Capacitance Bridge — 1 MHz
Model 75D



Extremely accurate measurements of a broad range of capacitance values may be made on this 100 kHz bridge. Test signal level is adjustable down to low values for semiconductor testing. 3-terminal arrangement permits use of remote test jig without errors owing to cable capacitance to ground. 2-terminal operation also provided. A linear detector mode for limit operation permits simple go/no-go testing. Both test and standard arms of the bridge are brought out to front-panel connectors for differential or comparison measurements. Balancing is simple and convenient with no false or sliding nulls. All zeroing controls are vernier driven. Internal or external dc bias. (For accessories see pages 10 and 11.)

Capacitance: 0 to 110,000 pF; basic accuracy, ± 0.1%; resolution, 0.0002 pF max.

Conductance: 0 to 1000 μmhos; bias accuracy, ± 5%; resolution, 0.001 μmho max.

Test Signal: 100 kHz; level continuously adjustable from 1 mV to 4 V.

DC Bias: Internal, −6 V to +100 V; external, up to ± 400 V.

Detector: Normal; AGC mode. Linear; no AGC, deflection proportional to bridge unbalance in pF. May be set from 0.002 pF fs to 4000 pF fs.

The Model 75C is a precise, high resolution bridge which makes direct reading measurements of capacitance, conductance, and parallel resistance over a frequency range that is continuously adjustable from 5 kHz to 500 kHz.

In providing the facility for measuring components, networks, and materials under widely adjustable conditions of test level, test frequency, and dc bias, the Model 75C comprises a research tool of substantial value.

Because this is a three-terminal instrument, remote measurements may be made via shielded cables, and the specimen may be mounted in a test fixture or in an environmental chamber without incurring errors resulting from stray capacitance from either side of the test to ground.

In addition to the TEST connections, the STANDARD arm of the bridge is also accessible through front panel BNC connectors, permitting use of external capacitors for differential or comparison measurements. This, combined with the instrument's excellent stability, makes the Model 75C particularly useful for high resolution temperature coefficient measurements. The Model 75C is completely self-contained including bridge circuitry, test oscillator, detector, and bias supply. (For accessories see pages 10 and 11.)

Capacitance: 0 to 1000 pF; basic accuracy, ± 0.25%; resolution, 0.0002 pF max.

Conductance: 0 to 1000 μmhos; bias accuracy, ± 5%; resolution, 0.001 μmho max.

Test Signal: Internally supplied; continuously adjustable in frequency from 5 kHz to 500 kHz; level adjustable from 1 mV to 3 V.

DC Bias: Internal only; continuously adjustable from −5 V to +110 V.

This bridge provides 3-terminal measurements of capacitance and conductance allowing remote connection without errors due to stray capacitance to ground. When measuring the higher capacitance values remotely, the effects of cable inductance may be negated by use of the Test Terminal Extender Model 71-6A (page 11). Makes 2-terminal measurements using Ground Plane Adapter Model 75-6A. Inductance is read by conversion from equivalent capacitance measurement. The null detector is extremely sensitive yet shows balance direction from the most extreme off-range setting. An additional differential detector mode allows capacitance or inductance sorting of components. Internal and external dc bias. (For accessories see pages 10 and 11.)

Capacitance: 0 to 1000 pF; basic accuracy, ± 0.25%; resolution, 0.00005 pF max.

Conductance: 0 to 1000 μmhos; basic accuracy, ± 5%; resolution, 0.01 μmho max.

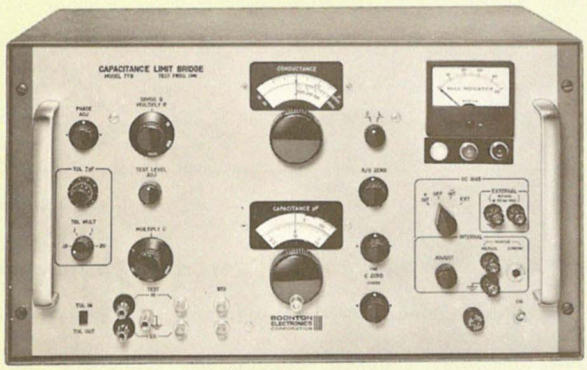
Inductance: 25 μH to 25 mH; basic accuracy, ± 0.25%.

Test Signal: 1 MHz, crystal controlled; level adjustable from 1 mV to 300 mV.

Dual External DC Bias: HI to GND and/or LO to GND; differential, ± 400V max.

Internal DC Bias: HI to LO; −6 V to +150 V.

Capacitance Limit Bridges



Capacitance Limit Bridge — 1 MHz
Model 77B

Performs automatic, high-speed, dual or single limit tests, or conventional manual measurements of capacitance or inductance. In automatic mode, test is insensitive to specimen loss. "High," "Low," or "Go" test decisions are indicated by front panel lamps as well as by continuity closures for actuation of material handling equipment. 3-terminal arrangement permits remote measurements at the end of coaxial cables without incurring error due to cable capacitance to ground. When measuring the higher capacitance values, the effects of cable inductance may be negated by use of the Capacitance Test Terminal Extender Model 71-6A. (See page 11.) Nominal capacitance values are set by the main capacitance balance dial in conjunction with its multiplier switch. A multi-turn control and range switch are used to program the desired tolerance. Operates with low test level. Built-in dc bias supply; provision for external bias. (For accessories see pages 10 and 11.)

Capacitance: Automatic mode, 0 to 1000 pF with 0.001 pF resolution max.; Manual mode, 0 to 1000 pF with 0.00005 pF resolution max.; basic accuracy, ± 0.25%.

Inductance: Manual or automatic, 25 μH to 25 mH; basic accuracy, ± 0.25%.

Conductance: (Manual only) 0 to 1000 μmhos; basic accuracy, ± 5%; resolution, 0.01 μmho max.

Tolerance Limits: Programmable at front panel controls from ± 0.0005 pF to ± 200 pF; basic accuracy, ± 0.25% of limit setting.

Test Time: Approx. 50 ms.

Test Signal: 1 MHz crystal controlled; level adjustable from 250 mV to 15 mV for Automatic mode, to 1 mV for Manual.

Decision Output: Green, red, and amber panel lamps indicating "Go," "High," and "Low," respectively; continuity contacts available at rear panel in conformance with test decisions.

DC Bias: Internal, continuously adjustable from −6 V to +150 V; external, to ± 400 V.

Capacitance Limit Bridge — 100 kHz
Model 77B-S1

Essentially similar to Model 77B. Has basic capacitance/inductance accuracy of ± 0.1%. Operates with internally supplied 100 kHz crystal controlled test signal. Capacitance range, automatic or manual, is 0.001 pF to 1000 pF. Inductance range, 2.5 mH to 250 mH. Otherwise specifications are as shown for Model 77B.

DC Meters

Sensitive DC Null Detector
Model 56A

This electronic galvanometer provides exceptionally high sensitivity and high input impedance. Especially valuable as indicator in conjunction with dc bridges. Zero-center scale. 60 dB scale compression in Hunt Mode virtually eliminates range switching when measuring specimens of unknown value. Provision for remote mode switching. Amplifier output available at front panel terminals. Either floating or grounded operation.

Voltage Sensitivity: 1 μV to 100 V end scale in 8 ranges.

Current Sensitivity: 0.1 pA to 10 μA, e.s.

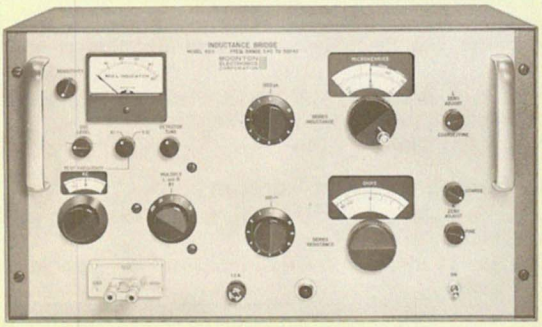
Input Resistance: 10 MΩ, all ranges.

Operating Modes: Hunt (60 dB meter scale compression); Calibrate (linear meter scale).

Amplifier Output Capability: ± 1 mA into 1000 Ω.

Amplifier Gain: −40 to +100 db.

Inductance Bridges



Inductance Bridges

These unique bridges provide direct-reading measurements of series inductance down to unusually low values with fractional percentage accuracy over broad frequency ranges. Series resistance is also directly measured. By proper design of these bridges, the adjusting elements for balancing L and R are independent. This eliminates the inconvenience of sliding nulls during the balancing operation. The inductance balance has a vernier dial that effectively gives a scale length of 200 inches. This, in combination with the inductance decade, gives excellent inductance readout resolution. Series resistance balance similarly employes a variable and decade control. Each bridge is complete with built-in oscillator and detector. Test current does not change during balance. An accessory mu jig may be used to make measurements of permeability and Q of toroidal cores. (See pages 10 and 11 for accessories.)

Model 63H

Inductance: 0.2 nH to 110 mH; basic accuracy, ± 0.25%.
Series Resistance: 0.2 mΩ to 11 kΩ; basic accuracy, ± 3%.
Test Signal: Frequency, 5 to 500 kHz; level, 3 V max.

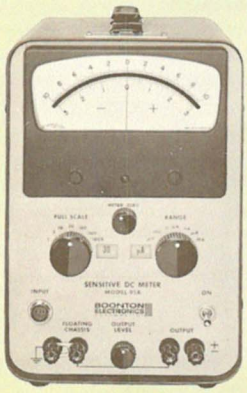
Model 63L

Inductance: 20 nH to 11 H; basic accuracy, ± 0.25%.
Series Resistance: 10 mΩ to 110 kΩ; basic accuracy, ± 3%.
Test Signal: Frequency, 0.4 to 40 kHz; level, 5.5 V max.

Model 63M

Inductance: 2 nH to 1.1 H; basic accuracy, ± 0.25%.
Series Resistance: 2 mΩ to 110 kΩ; basic accuracy, ± 3%.
Test Signal: Frequency, 1 to 100 kHz; level, 5.5 V max.

DC Meters

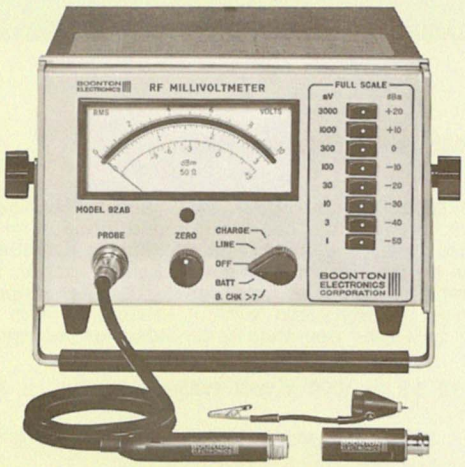


Sensitive DC Microvolt/Picoammeter
Model 95A

Unusually broad range of dc voltage and current measurements are covered in 42 ranges. Front panel range and function switching is uniquely simple and convenient with illuminated windows displaying the range in use. Zero-center meter. Fast response. Exceptionally stable amplifier output at front panel. Amplifier output gain and reference level is adjustable without interaction with meter. Either floating or grounded operation is provided for voltage; floating for current.

Voltage Range: 10 μV to 1000 V end scale; accuracy, ± 3% es; sensitivity, 1 μV.
Current Range: 1 pA to 1 A es; accuracy, ± 4% es; sensitivity, 0.1 pA.
Voltmeter Input Resistance: 10 MΩ, all ranges.
Amplifier Output: ± 1 V es across 1000 Ω.
Amplifier Gain: 100,000 max.

RF Millivoltmeters



Model 92A Series RF Millivoltmeters

These three programmable rf millivoltmeters offer an unrivaled choice of features and options to satisfy almost any application.

Analog and digital readout versions are available. Digital readout of dBm available. Digital readout dBm is optional on Model 92AD.

All are equipped with linear dc output, and BCD outputs are included as standard on the digital version.

Eight-line contact-closure programming is standard with logic-level programming and autoranging (92AD only) being optional.

Accuracy is the best ever offered for an rf millivoltmeter and the Boonton reputation of low-noise, drift-free operation is maintained.

One independent control calibrates each range making service adjustments an easy matter.

All units are supplied complete with rf probe, probe tip, and 50 Ω BNC adapter, and use the standard line of Boonton rf voltmeter accessories.

Single or dual rack mounting kits are available to adapt the trim 5.2 inch high package for 19 inch rack use.
(For accessories see pages 10 and 12.)

Model 92A Analog Readout Version

Voltage Range: 200 μV to 3 V (300 V up to 700 MHz with divider). Useful indications down to 100 μV.

Frequency Range: 10 kHz to 1.2 GHz (uncalibrated response to approximately 8 GHz).

Accuracy:

	1% fs, plus			
300 mV to 3 V	1% rdg	1% rdg	3% rdg	10% rdg
200 μV to 300*mV	2% rdg			7% rdg
	10 kHz	50 kHz	150 MHz 700 MHz	1.2 GHz

*Below 1 mV add 1% fs

Programming: External closure or PNP transistor to ground selects each range. Speed, 100 ms per range change.

DC Output: 0 to 10 V proportional to rf input voltage.

Options: Logic-level programming, many scale variations, rear input.

Model 92AD Digital Version

Voltage Range: 200 μV to 3 V (300 V up to 700 MHz with divider).

Display: Nixie-type, non-blinking, 3 digits + 1 for 50% overrange. Blanked for overrange and below 20% fs. Display period 250 ms; encode period 10 ms. Vertically-mounted edge-meter to right of display is calibrated in dBm, 50 Ω.

Data Outputs: 1-2-4-8 binary coded decimal information. 1-2-4 binary coded range information. Overrange, underrange, encode complete.

Commands: Encode hold, encode trigger, manual disable. Auto-enable and dBm-enable, as optioned.

Logic Levels: Logic 1 > 3 V; logic 0 < 0.3 V. TTL compatible.

Options: Autorranging, digital dBm readout, logic-level programming, rear input.

All other specifications are the same as Model 92A.

Model 92AB Battery Version

Battery Use/Charge Time: 16 h use for 14 h charge (charges at half rate during line operation).

All other specifications and options are the same as for Model 92A.

Model 91DA RF Millivoltmeter (Not Shown)

This rf voltmeter provides reliable, reproducible voltage measurements from the low radio frequencies to the gigahertz region.

Its versatility plus accuracy and convenience of operation have established it as a standard of performance for the industry. The Model 91DA is characterized by low noise, excellent stability, high input impedance, and low input capacitance. (For accessories, see Page 10.)

Model 91DA

Voltage Range: 300 μV to 3 V (300 V with divider).

Frequency Range: 20 kHz to 1.2 GHz.

Accuracy: Basically ± 2% fs.

RF Millivoltmeter Options

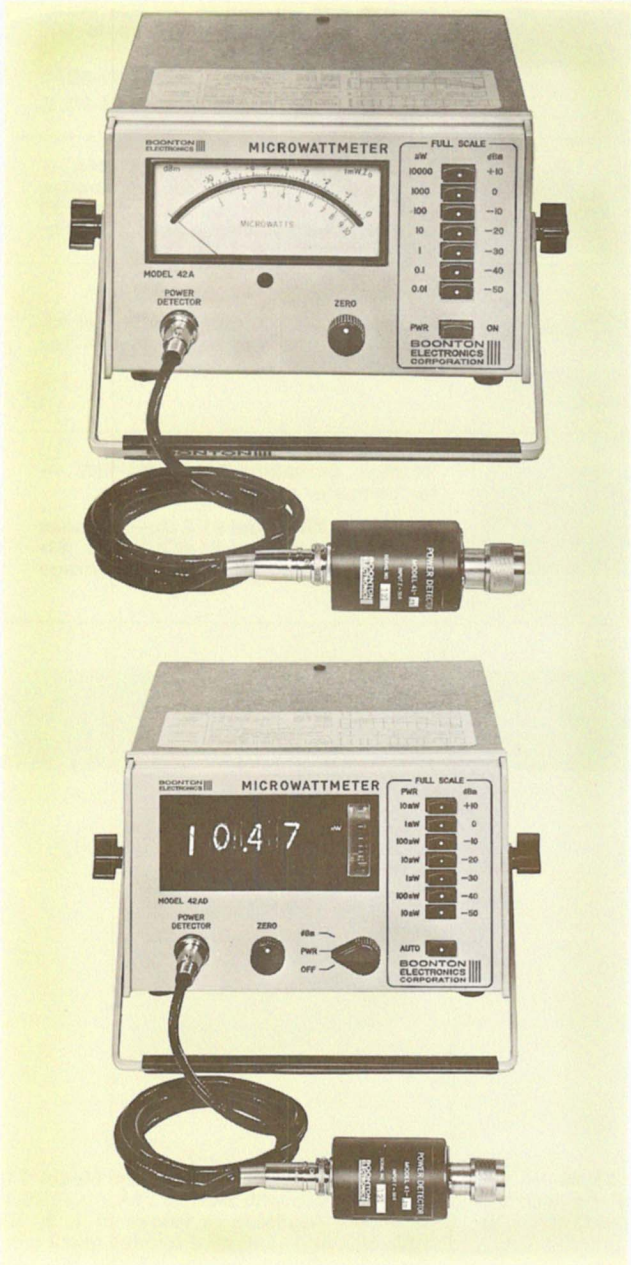
Options for Models 92A and 92AB

02 Logic-level programming
03-07 Various meter calibrations
08 Rear signal-input
12 dBmV CATV meter calibration (referred to 75 Ω)

Options for Model 92AD

01 Autoranging
02 Logic-level programming
08 Rear signal-input
09 dBm/mV readout (referred to 50 Ω)
10 dBm/mV readout (referred to 75 Ω)

RF Power Meters



Model 42 Series RF Microwattmeters

The new Model 42A and 42AD Microwattmeters are exceptionally sensitive programmable MF to K band (200 kHz to 12.4 GHz) power meters that virtually eliminate zero drift and temperature stability problems.

Three coaxial power detector heads, two 50 Ω and one 75 Ω are available. Each measures the full power range of from 1 nW to 10 mW with an overload rating of 0.3 W cw. The 75 Ω head for CATV applications has a frequency range from 200 kHz to 1 GHz.

Long-term absolute accuracy of the combined instrument and power detector is specified to allow the power meter to be used without frequent calibration checks.

Analog and digital readout versions are available. Digital readout of dBm is optional on the Model 42AD.

The dc output on both versions and the additional BCD outputs on the digital version are standard on the basic units. Single or dual rack mounting kits are available and adapt the trim 5.2 inch high package for 19 inch rack use. (See page 12.)

General Specifications:

Power Range: 1 nW to 10 mW (−60 to +10 dBm).

Full Scale Ranges: Seven, 10 nW fs to 10 mW fs.

Frequency Ranges: 200 kHz to 12.4 GHz (Standard Head); 200 kHz to 7 GHz (Low-cost Head); 200 kHz to 1 GHz (CATV Head)

Accuracy: 10 nW to 10 mW (−50 to +10 dBm)

0.5% fs plus*		
0.2 dB	0.3 dB	0.4 dB

1 nW to 10 nW (−60 to −50 dBm)

1% fs plus		
0.4 dB	0.5 dB	0.6 dB

200 kHz 4 GHz 8.2 GHz 12.4 GHz

*0.1% fs on Model 42AD

Stability: Zero, 1 nW/h max.; temperature, typically 0.007 dB/°C.

Programming: Closure or PNP transistor to ground selects range. Speed, 100 ms per range change.

Model 42A

Analog Version: 4½" taut band meter; two scales, power and dBm; dc output. Options: logic-level programming; reverse scales.

Model 42AD

Digital Version: 3½" digit power readout plus vertical edgemeter for analog readout of dBm. Display period 250 ms; encode period 10 ms. BCD outputs: linear dc output. Options: Logic-level programming; auto-ranging; digital dBm readout.

Options for Model 42A

02 Logic-level programming
08 Rear signal-input
11 Reverse scale (dBm as bottom)

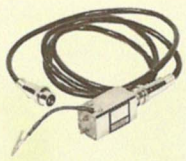
Power Detectors

41-4A 200 kHz — 7 GHz 50 Ω input
41-4B 200 kHz — 12.4 GHz 50 Ω input
41-4C 200 kHz — 1 GHz 75 Ω input

Options for Model 42AD

01 Autoranging
02 Logic-level programming
08 Rear signal-input
09 dBm/power readout

RF Voltmeter Accessories



Differential RF Probe Model 91-3E — for use with all listed RF Millivoltmeters. Responds to the difference of potential between two input terminals. Balanced input has a high impedance between each terminal and ground.

RF Probe Model 91-4C — for use with all listed RF Millivoltmeters. For measurements from 1 kHz to 250 MHz. Overload protection, 10 V ac and 200 V dc. Input capacitance, 2.5 pF down to 10 kHz rising to 25 pF at 1 kHz.

RF Probe Model 91-12E — for use with all listed RF Millivoltmeters. For measurement from 20 kHz to 1.2 GHz; useful response for relative measurements to beyond 4 GHz. Overload protection, 10 V ac and 400 V dc.

RF Probe Model 91-12F — for use with Model 92 series RF Millivoltmeters. For measurements from 10 kHz to 1.2 GHz. Other characteristics as Model 91-12E.

100:1 Voltage Divider Model 91-7C — for use with all probes, except Model 91-23A. Attenuates input signal by a factor of 100 (± 1%). permitting measurements up to 300 volts, and extending the rms measuring range to 3 volts, increases input resistance by a factor of 1000; operates from 50 kHz to 700 MHz. Maximum input potential, 1000 volts dc plus peak ac.

Probe Tip Model 91-13B — for use with Models 91-12E, 91-12F, 91-4C, and 91-7C. With grounding clip lead for use to approximately 100 MHz.

Unterminated BNC Adapter Model 91-6C — for use with all probes, except 91-23A. For coaxial connection up to approximately 100 MHz or to 400 MHz when fed from a 50 ohm source in an electrically-short system.

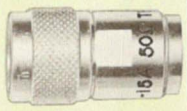
Unterminated Type N Adapter Model 91-16A — for use with all probes, except 91-23A. For coaxial connection up to approximately 100 MHz or to 400 MHz when fed from a 50 ohm source in an electrically-short system.

50 OHM BNC Adapter Model 91-8B — for use with all probes, except Model 91-23A. For measurements up to 600 MHz in a 50 ohm system.

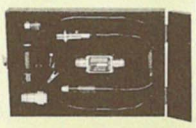
75 OHM BNC Adapter Model 91-8B/1.

93 OHM BNC Adapter Model 91-8B/2.

Type N TEE Adapter Model 91-14A — for use with Model 91-15A Termination (see below). Permits connection into 50 ohm line; frequency range to 1.2 GHz.



Type N 50 ohm Termination Model 91-15A — for use with Model 91-14A Tee Adapter.



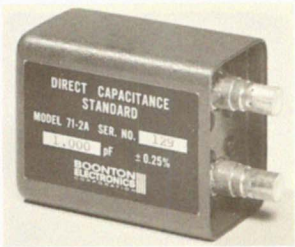
Storage Container Model 91-18A — for Voltmeter accessories.

Accessory Kit Model 91-24A — includes accessories Models 91-6C, 91-7C, 91-14A, 91-15A and Model 91-18A storage container.

Impedance Accessories

Precision Capacitance Standards Model CS — for use with Models 71, 74, 75, 77, and 700 Series. For checking accuracy of three-terminal capacitance bridges and meters. Basic accuracy, 0.1%. Capacitance values available from 0.01 pF to 1000 pF. Usable from 1 kHz to 1 MHz. Excellent electrical stability. Calibrated against references certified by NBS.

Standard Capacitor Model 71-1A — for use with Model 71A. 100 pF (± 0.25%). Provides both high Q and low Q (Q = 3) checks.



Plug-In Capacitance Standard Model 71-2A — for use with Models 71A, 71CR, 75D, and 700. Available in values of 1, 3, 10, 100, 300, and 1000 pF. Provides quick connect/disconnect feature without lead inductance error associated with the measurement of large capacitors (> 300 pF) at 1 MHz. Accuracy, ± 0.25%.

Decade Capacitor Model 71-3A — for use with Models 71, 74, 75, 77, and 700 Series. Maintains accuracy of ± 0.25% and is useful in the range of 5 kHz to 1 MHz. It is a three-terminal capacitor with selectable values of capacitance from 1 pF to 1221 pF in 1 pF increments. The unit can be used as a secondary standard for the calibration of capacitance bridges or capacitance meters. It may also be used as a reference capacitor for differential capacitance measurements.

Inductance Standard, 1 μH, Model 63-15A — for use with Model 63, 71, and 700 Series. Calibrated values of series inductance (± 0.5%) and series resistance (± 2%) given for frequencies of 10 kHz, 50 kHz, 100 kHz, and 500 kHz.

Mu Jig Model 63-11B — for use with Models 63, 71*, and 700* Series. A test fixture for convenient, rapid measurement of permeability and Q of toroidal cores within the size limitations at 1.9″ O.D.; 0.27″ I.D. for heights up to 0.31″, and 0.5″ I.D. for heights to 0.58″. The test jig plugs directly into the terminals of the bridge or may be operated at a distance from the bridge as long as reasonable care is taken to keep lead capacitance low and constant during measurements.

*Permeability only

Ultra-Low Inductance Adapter Model 71-10A — for use with Models 71A and 700. Two adapters permit full-scale measurements of 10 and 100 nanohenries. The adapters are equipped with both terminal posts and simple demountable loops. The terminal posts are useful for the measurement of the inductance of switches, printed-circuit boards, connectors, sockets, and other low inductance devices. The demountable loops are convenient for the measurement or comparison of the permeability of toroidal magnetic cores.

Model 71-10A/10 — 10 nanohenries fs.

Model 71-10A/100 — 100 nanohenries fs.

Range Extender (1 MHz) Model 77-2A — for use with Models 75D and 77B. Multiplies capacitance readings by 1000 (up to 0.1 μF), conductance readings by 1000 (up to 1 mho).

Range Extender (100 kHz) Model 77-3A — for use with Models 74D, 75C, and 77B-S1. Multiplies capacitance readings by 1000 up to 1 μF, conductance readings by 1000 up to 1 mho.

Range Extender (1 MHz) Model 71-12A — for use with Models 71A and 700 Series. Multiplies 10 pF fs capacitance range by 1000 allowing capacitance measurements to 10,000 pF.

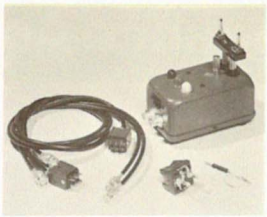
Capacitance Range Divider (1 MHz) Model 77-4A — for use with Models 75D, 71A, 700, and 77B. Permits division of the lowest capacitance range by a factor of 10.

Capacitance Range Divider (100 kHz) Model 77-5A — for use with Models 77B-S1, 71CR, and 74D. Permits division of the lowest capacitance range by a factor of 10.

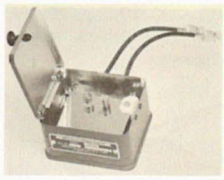
Capacitance Test Terminal Extender (1 MHz) Model 71-6A—for use with Models 75D and 77B. Permits physical separation of test specimen and Capacitance Bridge. Series inductance and shunt capacitance of cables are negated.

Capacitance Test Terminal Extender (1 MHz) Model 71-6B—for use with Models 71A and 700. Permits physical separation of test specimen and Capacitance Meter. Series inductance of cables is negated.

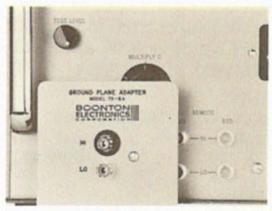
Inductance Test Terminal Extender (1 MHz) Model 71-7A—for use with Models 71A and 700. Permits physical separation of test specimen and C/L Meter. Series inductance and shunt capacitance of cables are negated.



Remote Test Fixture Model 77-1A — for use with Models 77B and 77B-S1. Jig comprises weighted box with red, green, and amber decision lights and HI, LO, and GND binding posts. Supplied with magnetic diode jig, spring component clip, HI, LO connecting cable, and connecting cable for decision lights.

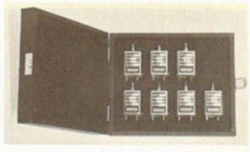


Three To Two-Terminal Adapter Model 75-5A — for use with Models 74D, 75A-S8, 75D, 77B, and 77B-S1. Allows use of 33-1A for dielectric measurements. Also allows use of 33-9A and 33-10A standards for correlation measurements between 33 series and 74, 75, and 77 Series Bridges.



Ground Plane Adapter Model 75-6A — for use with Models 75D, 77B, and 77B-S1. Permits the measurement of two-terminal capacitance on a three-terminal bridge.

Test-Signal Attenuator (Fixed 40 dB) Model 75-1A — for use with Models 74 and 75 series.



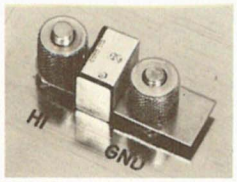
Set of 7 Work Coils Model 33-4A — for capacitance measurements with Models 33A and 33B. Supplied as standard equipment.

Set of 7 Work Coils Model 33-5A — for capacitance measurements with Models 33C and 33D. Supplied as standard equipment.

Set of 7 Work Coils Model 33-6A — for inductance measurements with Models 33A and 33B. Permits inductance measurements from 0.017 μH to infinity.

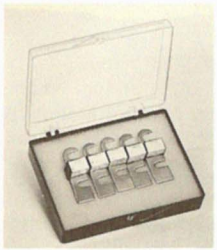
Set of 7 Work Coils Model 33-7A — for inductance measurements with Models 33C and 33D. Permits inductance measurements from 0.017 μH to infinity.

Impedance Accessories



Standard Capacitors Model 33-9A — for use with Model 33 Series for checking capacitance calibration. Available in 9 nominal values, 5, 10, 20, 30, 50, 75, 100, 125 and 145 pF. Basic accuracy, 0.25%.

Conductance Standards Model 33-10A — for use with Model 33 Series for checking conductance calibration. Available in 10 nominal values, 2, 10, 20, 100, and 200 μmhos; 1, 2, 4, 10, and 20 mmhos. Accuracy, $\pm$ 0.5% at 1 MHz.



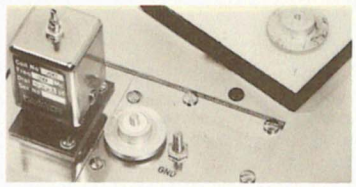
Set of Capacitance Standards Model 33-17A — for use with Models 33A and 33B. Nominal values, 5, 10, 20, 30, 50, 75, 100, 125, and 145 pF.

Set of Conductance Standards Model 33-18A — for use with Models 33A and 33C. Nominal values, 10 and 100 μmhos; 1, 10, and 20 mmhos.

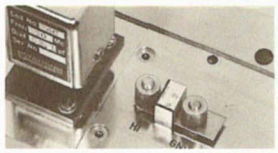
Set of Conductance Standards Model 33-19A — for use with Models 33B and 33D. Nominal values, 2, 20, and 200 μmhos; 2 and 4 mmhos.

Combination set of Capacitance and Conductance Standards Model 33-14A — comprises 33-17A set of capacitance standards and 33-18A set of conductance standards. For use with Model 33A.

Combination set of Capacitance and Conductance Standards Model 33-16A — comprises 33-17A set of capacitance standards and 33-19A set of conductance standards. For use with Model 33B.



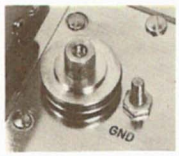
Zero Conductance Standard Model 33-8A — for use with Model 33 Series. Serves as a sensibly lossless capacitor adjustable up to approx. 50 pF to establish conductance correction when testing high Q devices.



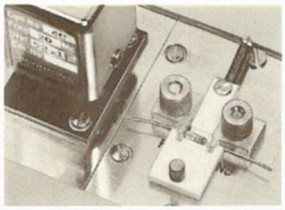
Range Extending Capacitors Model 33-11A — for use with Models 33A and 33B. Permits extension of capacitance measuring range by substitution method. Available in nine nominal values from 225 pF to 1425 pF. Provide 150 pF to 1500 pF extensions, depending on frequency (each capacitor requires use of a 33-12A work coil). (Request supplementary list.)

Range Extending Work Coils Model 33-12A — for use with Models 33A and 33B. One coil needed for each Model 33-11A capacitor at each frequency. (Request supplementary list.)

Storage Box Model 33-13A — for use with Model 33 Series. Accommodates up to 8 work coils.

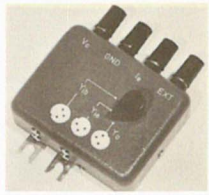


Dielectric Sample Holder Model 33-1A — for use with Model 33 Series directly, and Models 74, 75, and 77 Series in conjunction with Model 75-5A, 3 to 2-Terminal Adapter. Order 75-5A separately. Accepts specimens up to 0.130" thick for dielectric studies.



Diode Test Fixture Model 33-2A — for use with Model 33 Series. Provides convenient means for connecting axial lead diodes to test terminals.

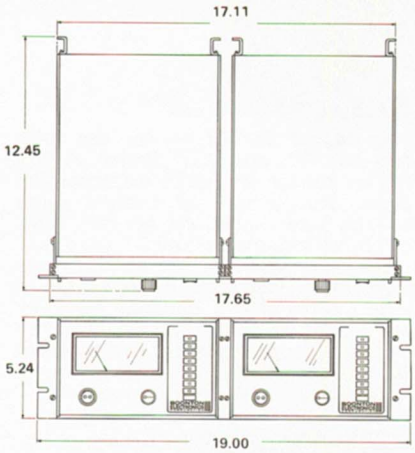
Type N Coaxial Adapter Model 33-3A — for use with Model 33 Series. For coaxial connection to test terminals.



Y Parameter Fixture Model 33-20A — for use with Model 33 Series. Three transistor sockets are arranged for measuring Y_{ie}, Y_{ib}, and Y_o. The 33-20A, which includes circuitry for external bias, uses minimum lead length for high frequency measurements. Terminal posts are provided for external biasing and a switch selects the correct bias configuration.

Attenuator Model 33-15A — for use with Model 33C. Reduces test signal level to below 1 mV at all test frequencies.

HARDWARE



Rack Mounting Kits Models 92-1A and 92-1B — converts Models 92 and 42 Series for 19 inch rack mounting.

Model 92-1B Dual Rack Mounting Kit is illustrated. Model 92-1A Kit is similar except that a blank half-rack panel is supplied instead of one of the two mounting frames.

BOONTON ELECTRONICS CORPORATION

Automation Products: In addition to the equipment shown in this catalog, Boonton Electronics Corporation also produces a line of instruments and systems for high-speed, automatic testing and manufacturing process control in electronic component and microcircuit production. This line includes: automatic resistance limit bridges, automatic resistance trimming bridges, automatic capacitance test systems, and resistance and capacitance scanning systems, among many others. Full information on this equipment is provided in our catalog of "Automation Products," available on request.

Route 287 at Smith Rd., Parsippany, N. J. 07054 TEL: 201-887-5110 TWX: 710-986-8241

Printed in U.S.A.

15M 5/71 ID

BOONTON ELECTRONICS CORPORATION
PARSIPPANY, NEW JERSEY U.S.A.

Price List IP2
INSTRUMENTS
OPTIONS &
ACCESSORIES

Effective April 1, 1972
Supersedes October 1, 1971

INSTRUMENTS

MODEL	UNIT PRICE	DESCRIPTION
33A/1	$3245.	RF Admittance Bridge
33B/1	3865.	
33C/1	3450.	
33D/1	4120.	
35A	4635.	Q Bridge
42A	670.*	RF Microwattmeter
42AB	825.*	
42AD	925.*	
63H	3040.	Inductance Bridge
63L	3295.	
63M	3040.	
71A	1080.	Capacitance/Inductance Meter
71AR	1160.	
71CR	1235.	
72A	875.	Capacitance Meter
72AD	1135.	
74D	1995.	Capacitance Bridge
75C	2885.	
75D	2215.	
77B	2935.	Capacitance Limit Bridge
77B-S1	2935.	
91C	610.	RF Voltmeter
91DA	747.	Sensitive RF Voltmeter
91H	710.	
91K	775.	High Z RF Millivoltmeter
91L	1090.	Microwave Millivoltmeter
92A	775.	RF Millivoltmeter
92AB	925.	
92AD	1025.	
92C	595.	
93AD	1135.	True RMS Voltmeter
95A	645.	Sensitive DC Meter
102A	2700.	FM/AM Signal Generator
172A	2700.	Capacitance Ratio Meter
700C	2680.	Digital C/L Meter

* Price does not include power detector.
Select detector below.

POWER DETECTOR		IMPEDANCE	FREQUENCY RANGE
41-4A	$175.	50 Ω	200 kHz - 7 GHz
41-4B	275.	50 Ω	200 kHz - 12.4 GHz
41-4C	175.	75 Ω	200 kHz - 1 GHz
41-4D	300.	50 Ω	12 GHz - 18 GHz

OPTIONS

MODEL	SUFFIX	PRICE	DESCRIPTION
42A	02	$ 75.	Logic Level Programming
42AB	08	25.	Rear Signal Input
	11	25.	dBm Scale Uppermost
42AD	01	150.	Autoranging
	02	75.	Logic Level Programming
	08	25.	Rear Signal Input
	09	100.	dBm Display
72AD	01	150.	Autoranging
92A	02	75.	Logic Level Programming †
92AB	03	25.	dBV Scale
92C	04	25.	dBV Scale Uppermost
	05	25.	75 Ω dBm Scale*
	06	25.	75 Ω dBm Scale Uppermost*
	07	25.	50 Ω dBm Scale Uppermost
	08	25.	Rear Signal Input
	12	25.	dBmV Scale Uppermost*
92AD	01	150.	Autoranging
	02	75.	Logic Level Programming
	08	25.	Rear Signal Input
	09	100.	50 Ω dBm Display
	10	100.	75 Ω dBm Display*
93AD	01	150.	Autoranging
	08	25.	Rear Signal Input
	09	100.	50 Ω dBm Display
	10	100.	75 Ω dBm Display
	15	100.	600 Ω dBm Display

† Not available on Model 92C

* Supplied with 91-8B/1 75 Ω BNC Adapter

ORDERING INFORMATION

All prices F.O.B. Parsippany, New Jersey U.S.A.
Terms: Net 30 days
State and local taxes not included.
Minimum order value, $15.00
All quotations to U.S. Government agencies must be issued by the factory.
Prices subject to change without notice.

NOTES

Add $50.00 for special paint.

This Price List applies for both U.S. Domestic and Overseas sales.

ACCESSORIES

MODEL	PRICE	DESCRIPTION
CS	$145.	Capacitance Standard
TS1	6.	Terminal Shield
33-1A	100.	Dielectric Sample Holder
33-2A	70.	Diode Test Jig
33-3A	70.	Coax N Adapter
33-4A	140.	Set of Work Coils for
33-5A	140.	Capacitance Measurement
33-6A	140.	Set of Work Coils for
33-7A	140.	Inductance Measurement
33-8A	45.	Zero Conductance Standard
33-9A/1 to /9	35.*	Capacitance Standard
33-10A/1 to /10	35.*	Conductance Standard
33-11A/1 to /9	40.*	Range Extending Capacitor
33-12A/1 A to J	40.*	Range Extending Coil
33-12A/2 A to J	40.*	
33-12A/3A to J	40.*	
33-12A/4 A to C	40.*	
33-12A/5A	40.	
33-13A	17.	Storage Case
33-14A	455.	Set of C & G Standards
33-15A	30.	Attenuator
33-16A	455.	Set of C & G Standards
33-17A	300.	Set of Capacitance Standards
33-18A	165.	Set of Conductance Standards
33-19A	165.	
33-20B	200.	Y Parameter Fixture
41-2A	17.	Detector Cable
41-4A	175.	Power Detector
41-4B	275.	
41-4C	175.	
41-4D	300.	
63-11B	175.	"Mu Jig" Test Fixture
63-15A	115.	Inductance Standard
71-1A	85.	Capacitance Std. & Q Check
71-2A/1 to /7	85.*	Capacitance Standard
71-3A	400.	Precision Decade Capacitor
71-6A	200.	Capacitance Test
71-6B	200.	Terminal Extender
71-7A	145.	Inductance Term. Ext.
71-10A/10	300.	Low Inductance Adapter
71-10A/100	250.	
71-12A	150.	Capacitance Range Ext.
72-4A	30.	Test Post Adapter
72-5A	30.	

*Price is for each item. See Supplementary Lists for values available.

ACCESSORIES

MODEL	PRICE	DESCRIPTION
75-1A	$ 30.	Attenuator
75-5A	137.	3 - 2 Terminal Adapter
75-6A	40.	Ground Plane Adapter
77-1A	137.	Remote Test Fixture
77-2A	200.	Capacitance Range Extender
77-3A	200.	
77-4A	137.	Capacitance Range Divider
77-5A	137.	
91-3A	115.	RF Probe*
91-3E	140.	Differential RF Probe
91-4C	115.	Low Frequency RF Probe
91-6C	35.	Unterminated BNC Adapter
91-7C	57.	100: 1 Voltage Divider
91-8B	46.	50 Ω BNC Adapter
91-8B/1	68.	75 Ω BNC Adapter
91-8B/2	68.	93 Ω BNC Adapter
91-12D	85.	RF Probe*
91-12E	—	RF Probe (order 91-12F below)
91-12F	85.	RF Probe
91-13B	8.	Probe Tip
91-14A	75.	50 Ω Tee Adapter N
91-14A/1	110.	75 Ω Tee Adapter N
91-15A	45.	50 Ω Termination N
91-15A/1	60.	75 Ω Termination N
91-16A	35.	Unterminated N Adapter
91-17D	115.	Low Frequency RF Probe*
91-18A	17.	Storage Box
91-19B	17.	Storage Bracket
91-24A	180. When ordered with any listed RF millivoltmeter	Set of Accessories, 50 Ω
91-24A/1		Set of Accessories, 75 Ω
	229. When ordered NOT at the same time	50 Ω Set: 91 – 6C, 91 – 7C, 91 – 14A, 91 – 15A, 91 – 18A 75 Ω Set: 91 – 6C, 91 – 7C, 91 – 14A/1, 91 – 15A/1, 91 – 18A
92-1A	50.	Rack Mounting Kit
92-1B	50.	
93-1A	95.	High-Impedance Probe

* Obsolete items, for replacement only

ROUTE 287 AT SMITH RD., PARSIPPANY, N. J. 07054 U.S.A. • TEL.: 201-887-5110 TWX: 710-986-8241

BOONTON ELECTRONICS CORPORATION
PARSIPPANY, NEW JERSEY

Models 33A/1 B/1 C/1 & D/1 RF Admittance Bridges

Precise, High-Resolution Measurements of Admittance / Impedance at 1 MHz to 100 MHz

- Capacitance Range: 0 to 150 pF * (33A/1)
  Basic Accuracy: 1%
  Resolution: 0.02 pF
- Conductance Range:
  0 to 25,000 μmhos (33A/1)
  Basic Accuracy: 2%
  Resolution: 1% +0.5 μmho
- High Capacitance & Conductance Resolution Models 33B/1 C/1 & D/1 (see specifications)
- Shunt or series resistance and inductance, dissipation factor, and Q may also be readily determined.
- Test Frequencies: 1, 5, 10, 20, 30, 50, and 100 MHz; all crystal controlled
- Operates with low test signal levels; continuously adjustable up to at least 100 mV (33A/1)
- Low distortion test signal prevents errors resulting from turn-over effect
- DC Bias: Internal, −5 V to +100 V; external, to ±250 V

* 0 to 30 pF at 100 MHz. Capacitance range extension available at 30 MHz & below.

- Invaluable for measurements of semiconductor devices, including integrated circuits
- Some typical applications are:

  Capacitance and loss measurements of diodes (particularly varactors and tunnel diodes)

  Measurements of transistors (including F.E.T.'s)

  Measurements of resistors, capacitors, inductors, connectors, and transmission lines

  Determination of dielectric constants including those of thin films

  Measurement of permeability and loss of magnetic materials

GENERAL DESCRIPTION

The Model 33 is a precision admittance bridge whose ability to measure directly both capacitance and conductance at high frequencies with superb resolution and with extremely low test signal levels sets it apart from all other commercially available instruments.

The balance network of the Model 33 (patent applied for) was developed by John H. Mennie of Boonton Electronics Corporation. It represents an important advance in the art of rf impedance measurement.

Shunt inductance and parallel resistance may also be measured with the Model 33 . In addition, such quantities as Q, dissipation factor, dielectric constant, and permeability may be conveniently determined.

The instrument includes a dc supply for biasing the test specimen as well as provision for external bias. An internal test signal generator supplies seven crystal controlled frequencies ranging from 1 to 100 MHz. These circuits, together with the RF bridge network and null detector, are packaged in a single, compact bench cabinet.

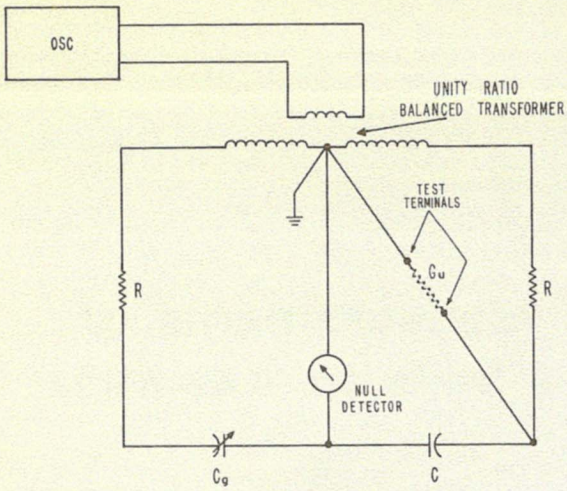


Figure 1a

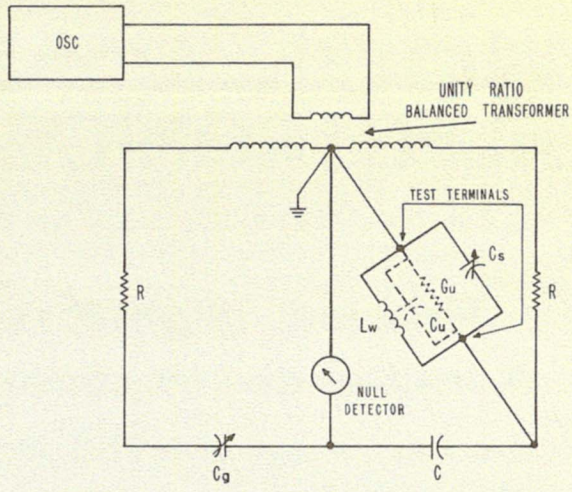


Figure 1b

Figure 1. Simplified schematics of Model 33 Bridge Circuit

BASIC BRIDGE CIRCUIT

The unique characteristics of the Model 33 are made possible by the bridge circuit, a simplified diagram of which is shown in Figure 1.

Conductance Measurement — In the configuration shown in Figure 1a, the network is balanced when:*

$$G_u = \frac{\frac{C}{C_g} - 1}{R}.$$

Thus the conductance of the test specimen, G_u, may be measured in terms of the capacitance removed from the circuit by adjustment of the calibrated air capacitor (C_g) to restore the balance of the bridge.

Capacitance Measurement — The network shown in Figure 1a measures conductance only. Addition of the resonant circuit, C_s and L_w, across the test terminals (See Figure 1b) provides means for measuring the effective capacitance of the test specimen, C_u.

When this circuit is initially brought to resonance at the test frequency, the bridge sees it only as a low value of pure conductance which can be easily balanced out when the bridge is initially zeroed.

When the specimen is placed across the test terminals, the capacitance it adds is determined from the amount of capacitance removed by adjustment of the calibrated air capacitor, C_s, to return the network to resonance, as indicated by restoring the balance of the bridge.

MODEL 33 BRIDGE CIRCUIT

In applying this basic concept to the Model 33 , the function of C_g is performed by a precision, highly stable air capacitor which is calibrated in micromhos. The helical conductance scale is effectively more than 34 inches long, providing excellent readability over the total range of zero to 25,000 micromhos.

C_s, also a precision air capacitor, serves as the main capacitance control of the Model 33 . With the arrangement of the outer "counter dial" plus the 10-to-1 vernier each picofarad occupies a full inch on the scale, again assuring excellent resolution of readout.

* For derivation of this balance equation, see Boonton Electronics Technical Report No. 21, available on request.

The inductance, L_w, in the resonant network (Figure 1b) is provided by an external inductor, or "work coil", which attaches to connector posts located on top of the cabinet. The seven work coils required for operation over the total range of the Model 33 are supplied (complete with a sturdy storage container) as standard equipment with the instrument.

In the Model 33 two additional controls are added to the simplified bridge circuit shown in Figure 1b, both of which contribute to convenience of operation. A small variable air capacitor inserted in series with C_g permits balancing out the loss of the resonant circuit so that the conductance measurements can be made from a zero reference point. Another small variable air capacitor is placed in parallel with C_s, again to permit capacitance readings from a zero reference. Front panel markings of these two adjustments are G ZERO and C ZERO, respectively (see Figure 2).

This bridge circuit provides a number of important advantages: The use of air capacitors as the variable elements provides "infinite resolution" controls, and eliminates problems of noise, wear, and frequency restriction commonly associated with even the best potentiometers.

In addition, this circuit avoids the complexities introduced by the use of double-shielded transformers for coupling to a grounded signal source or null detector. Their limited frequency range, low impedance, and inter-shield capacitance across the arms of the bridge all would work to the substantial detriment of the instrument's wide operating range.

The basic simplicity of both the circuit and its shielding requirements results in only small values of residual reactance which are easily compensated under all operating conditions.

Since all shunt reactances both of the test specimen and of the measuring system are completely neutralized when the bridge is balanced, their effects do not mask the equivalent conductance of the test. As a result, measurements can be made of small values of capacitance and conductance with high resolution, even with low test signal levels.

Another characteristic of this bridge circuit is that interaction between the arms of the bridge is eliminated, avoiding the annoyance and ambiguity of false nulls and sliding balance.

Mechanical linkages between the panel controls, calibrated scales, and their respective variable capacitors all have been engineered and manufactured to reduce backlash to an absolute minimum, with the result that it may be discounted from the standpoints of accuracy and resolution.

TEST SIGNAL

Since stability of the test signal frequency is vital to the accuracy of measurement, each of the seven internally supplied test frequencies is crystal controlled. Harmonic distortion of the test signal waveform is held to a minimum, eliminating errors in measurement resulting from turnover effects, a point of major importance in measurements on semiconductors.

The test signal level is continuously adjustable from a maximum of at least 100 millivolts to as low as 1 millivolt (5 millivolts at 100 MHz). Operation at even lower test levels is possible under some circumstances. It is important to note that adjustment of signal level has no effect whatever upon the test frequency.

The amplitude of the test signal may be measured and set to a specific level with any of the Boonton Electronics Sensitive RF Voltmeters, Model 91- Series. When the bridge is balanced with the RF Voltmeter and test specimen connected, the desired level may be accurately set. When the meter is removed and the bridge rebalanced, the test voltage returns to the pre-set level.

NULL DETECTOR AND INDICATOR

The null detector of the Model 33 is of the superhetrodyne type. The local oscillator is crystal controlled and selection of the test frequency simultaneously selects the appropriate local oscillator frequency. No further tuning is required. Gain of the null detector amplifier is adjustable at the front panel so that the optimum conditions of system noise and sensitivity can be selected. Adjustment of detector sensitivity in no way effects test signal frequency or level.

DC BIAS

An internal, regulated dc supply provides bias for the test specimen which is continuously adjustable from −6 volts to +100 volts. It may be monitored by connecting a dc meter to front panel jacks. Provision is also included for application of externally supplied bias up to ±250 volts, dc. Both the resistance and inductance of the external bias channel have been held to extremely low values so that high current tunnel diodes may be tested without oscillation.

INDUCTANCE AND RESISTANCE MEASUREMENTS

Effective shunt inductance can be readily determined with the Model 33 . By selecting a work coil which brings the bridge to balance up-scale rather than at "zero picofarads" the effective "negative capacitance" of the test sample may be measured, and the shunt inductance then computed from well established relationships, i.e., $L = 1/\omega^2 C$.

While measurements of inductance can be made with many of the work coils provided with the instrument, an additional set of coils intended specifically for this purpose is available as a separate accessory. These coils permit balancing the bridge at full scale capacitance (150 pF) at all frequencies, and provide a more convenient means for making such measurements. (see "Impedance Accessories" listing page 48).

The Model 33 is calibrated in micromhos which may, of course, be readily converted to ohms of parallel resistance, or to dissipation factor or Q. Series resistance may also be determined from established equations.

APPLICATIONS

The applications for the Model 33 may be divided into two basic areas: (a) precision, high resolution measurement of RF admittance on a wide range of semiconductor devices; and (b) general high frequency impedance and loss measurements on a great variety of components.

Semiconductor Measurements — The unique capabilities of the Model 33 make possible vital capacitance and loss measurements on solid state devices at high frequencies and low test levels with an accuracy and resolution that has never before been possible. In addition, a number of

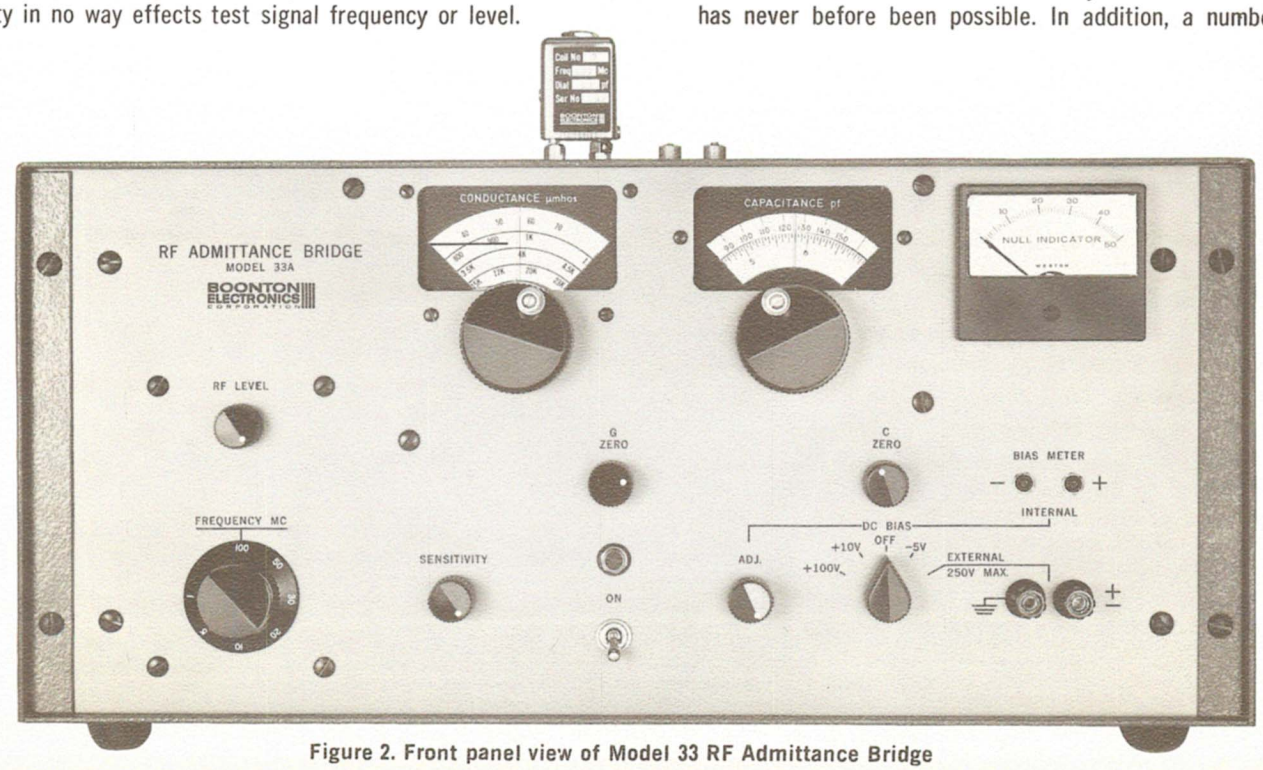


Figure 2. Front panel view of Model 33 RF Admittance Bridge

features have been incorporated which add materially to the convenience and efficiency of measurement. For example, the ability to bias the specimen over a wide range of values from a built-in regulated supply plus the facility for adjusting and monitoring this bias level at the front panel are of particular importance in tests on such voltage sensitive components as voltage variable capacitor diodes.

An important application for the Model 33 involves measurements on integrated circuits. Here, in addition to measuring the stray capacitance and the capacitance and loss of individual components on the substrate, the Model 33 is of great value in determining the effectiveness of isolation of elements, whether the circuit is constructed by either P-N junction or by dielectric isolation.

The Model 33 is also extremely useful for capacitance and loss measurements on transistors of all types (including FET's), as well as for determination of a number of h, y, and z parameters.

General RF Impedance Measurements — In impedance measurements on a wide range of high frequency components there is a distinct advantage in testing at or near the frequency at which the device is to be used, rather than measuring at low frequency and then attempting to extrapolate. Many phenomena such as skin effect and distributed capacitance are extremely difficult or impossible to detect at lower frequencies.

Typical of the components for which the Model 33 is useful are connectors, switches, resistors, capacitors, and inductors, in addition to such assemblies as high frequency attenuators, and pulse forming networks. The instrument also provides means for determination of phase and attenuation constants of cables, as well as their characteristic impedances.

The Model 33 is equally useful for a number of measurements on broad band transformers. These include determination of primary inductance, or leakage and mutual inductance, and of coupling coefficients. Since these devices are frequently quite lossy, their Q's are often too low for measurement on other types of high frequency instrumentation.

MATERIAL CONSTANT STUDIES

This bridge is a valuable tool in the study of dielectric constants. The Model 33-1A Dielectric Sample Holder is intended specifically for use with the Model 33 , and accepts sheet materials having thicknesses from a maximum of 0.13" down to approximately 0.005" or less. The dielectric constant is determined by comparing the capacitance of the fixture containing the sample minus fringe capacitance to the calculated capacitance of the fixture with an equivalent air gap.

The Model 33 may also be used in determining effective permeability and loss of magnetic materials, particularly of toroidal cores.

CAPACITANCE RANGE EXTENSION

The capacitance range of the Model 33 can be extended above 150 pF by the substitution method through the use of the Model 33-11A Range Extending Capacitors. The range may be extended in increments of 150 pF to a limit of 1500 pF up to 10 MHz, to 600 pF up to 20 MHz, or to 300 pF up to 30 MHz. For full details, contact your local Boonton Sales Engineering Representative or call the factory directly.

SPECIFICATIONS, MODEL 33A/1

Capacitance Range: 0 to 150 pF — 1 MHz to 50 MHz
0 to 30 pF — 100 MHz

Accuracy: $\pm$ (1% + $\frac{f}{100}$% + 0.05 pF)

Resolution: 0.02 pF for 50 mV test level at 1 MHz‡

Conductance Range: 0 to 25,000 μmhos

Accuracy: $\pm$ (2% + $\frac{Qf}{1000}$ % + 0.5 μmho)*

Resolution: 0.5 μmho for 50 mV test level at 100 MHz‡

Inductance Range: 0.02 μH to ∞ at 100 MHz

Accuracy: $\pm$ (1% + $\frac{10}{C}$ % + 0.01 μH)**

Test Signal Frequencies: 1, 5, 10, 20, 30, 50, and 100 MHz
Accuracy: $\pm$0.01% (crystal controlled)
Maximum Level: 100 mV (+300% —10%) continuously adjustable to —
Minimum Level: <1 mV from 1 MHz to 10 MHz increasing to approx. 5 mV at 100 MHz

D.C. Bias Internal: —6 V to +100 V continuously adjustable
External: $\pm$250 V dc maximum

Primary Power: 105/125 V or 210/250 V, 50/60 Hz, 45 W

SPECIFICATIONS, MODEL 33B/1

This alternate version of the RF Admittance Bridge offers extra high conductance resolution thus allowing more accurate measurement of the lower values of conductance. In all respects other than those specified below it is identical to the standard Model 33A.

Capacitance Resolution: 0.02 pF for 10 mV test level at 1 MHz†

Conductance Range: 0 to 5000 μmhos

Accuracy: $\pm$ (2% + $\frac{Qf}{15000}$ % + $\frac{3f}{1000}$ μmho + 0.1 μmho)

Resolution: 0.1 μmho for 30 mV test level at 100 MHz‡

Test Signal Maximum Level: Varies from 100 mV at 1 MHz to 30 mV at 100 MHz

SPECIFICATIONS, MODEL 33C/1

This alternate version of the RF Admittance Bridge offers extra high capacitance resolution thus allowing more accurate measurement of the lower values of capacitance. In all respects other than those specified below it is identical to the standard Model 33A.

Capacitance Range: 0 to 15 pF (all frequencies)

Accuracy: $\pm$ (1% + $\frac{f}{100}$% + 0.005 pF)

Resolution: 0.002 pF for 100 mV test level at 5 MHz‡

Inductance Range: 0.2 μH to ∞ at 100 MHz

SPECIFICATIONS, MODEL 33D/1

This alternate version of the RF Admittance Bridge offers extra high capacitance and conductance resolutions thus allowing more accurate measurements of the lower values of both capacitance and conductance. In all respects other than those specified below, it is identical to the standard Model 33A.

Capacitance Range: 0 to 15 pF (all frequencies)

Accuracy: $\pm$ (1% + $\frac{f}{100}$ % + 0.005 pF)

Resolution: 0.002 pF for 100 mV test level at 1 MHz‡

Conductance Range: 0 to 5000 μmhos

Accuracy: $\pm$ (2% + $\frac{Qf}{15000}$ % + $\frac{3f}{1000}$ μmho + 0.1 μmho)

Resolution: 0.1 μmho for 30 mV test level at 100 MHz‡

Inductance Range: 0.2 μH to ∞ at 100 MHz

* Where "Q" is Q factor of test component and "f" is frequency in MHz.
** Where "C" is the resonating capacitance of the sample in pF.
† Resolution better at higher frequencies for same level.
‡ Resolution better at lower frequencies for same level.

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BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY

MODEL 33-20B
Y PARAMETER FIXTURE

The 33-20B Y Parameter Fixture was designed for use with Boonton Electronics Model 33 series RF Admittance Bridges to measure the y parameters of transistors.

A series of three 4 pin transistor sockets are arranged for measuring y_{ie}, y_{ib}, and y_o. The fixture uses minimum lead length to accomplish each two-terminal y parameter measurement. Terminal posts provide means for connecting external bias supplies, and a switch selects the correct bias configuration for each socket.

The measurable y parameters are defined as follows:

$y_{ie} = \frac{i_e}{v_e}$	$v_c = 0$	Common emitter input admittance, output shorted
$y_{ib} = \frac{i_b}{v_b}$	$v_c = 0$	Common base input admittance, output shorted
$y_{oe} = y_{ob} = \frac{i_c}{v_c}$	$v_e = v_b = 0$	Common emitter/base output admittance, input shorted

The Model 33/A1 Admittance Bridge is a superior instrument for the measurement of y parameters. Among its distinct advantages are: 1) continuous adjustment of the test level (from about 0.3 V to a few millivolts, or less) without affecting the frequency or initial balance: 2) a conductance range of 1 μmho to 25 mmhos with a resolution of 0.5 μmho; 3) a capacitance range of zero to 150 pF (limited to 30 pF at 100 MHz) with a resolution of 0.02 pF; and 4) a frequency range of 1 to 100 MHz (seven selectable, crystal-controlled frequencies). Special versions of the 33A/1 are available with an improved resolution of 0.1 μmho and/or 0.002 pF. See specifications for Models 33B/1, 33C/1 and 33D/1.

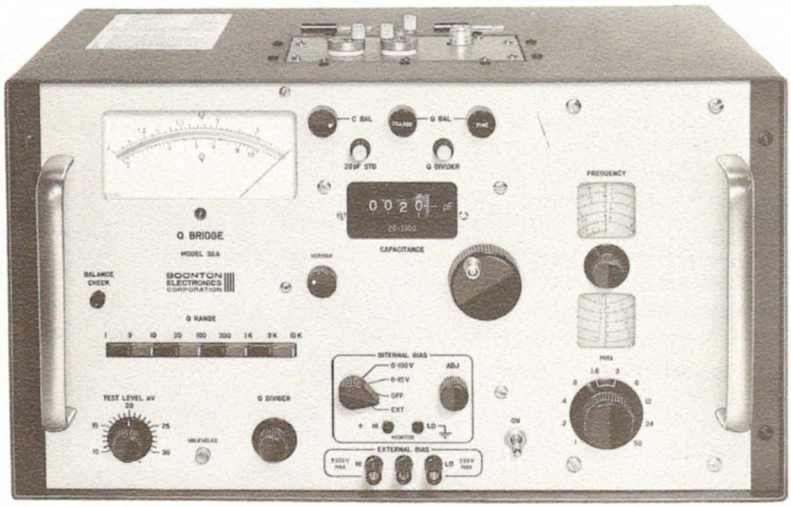
St. No. 2979 8/72

BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY

Preliminary Data

Model 35A Q Bridge

Measurements of Q & Capacitance From 100 KHz to 50 MHz with Low Test Levels



- Capacitance, 2 pF to 10,000 pF, from 100 kHz to 50 MHz
- Q, 5 to 10,000 (limited for indirect measurements)
- Indirect capacitance measurements: 0.005 to 20 pF, from 100 kHz to 50 MHz 1000 pF to 0.25 μF, from 100 kHz to 1 MHz
- Inductance, 0.1 μH to 100 mH
- Test frequency continuously adjustable from 100 kHz to 50 MHz
- Built-in oscillator and detector; ganged for one-dial tuning
- Low test-signal level for testing solid-state devices
- Non-resonant bridge; no work coil required
- 3-terminal arrangement permits remote measurements
- Dual external dc bias; single internal bias

The Model 35A is a new, non-resonant, three-terminal bridge which provides direct-reading measurements of capacitance and its Q over wide ranges, with continuously adjustable test frequency. The instrument is valuable for measurements on a wide variety of capacitors, particularly varactors of larger values and high Q devices such as ceramic capacitors. With the test frequency continuously adjustable over a wide range, the Model 35A is useful for studying the frequency characteristics of both components and materials.

The basic capacitance measuring range of the Model 35A is from 20 pF to 1000 pF, with capacitance read directly from a mechanical counter calibrated over this range.

The Q of the test is read directly from the front panel meter (times range multiplier). The Q range of 5 to 10,000 is covered in 8 steps in 1-3-10 sequence. Since this is a non-resonant bridge circuit, there is no requirement for a resonating inductance which would tend to mask the Q of the test.

Since all 4 corners of the bridge are accessible at the terminal plate on top of the instrument, modification of the bridge arms by use of external accessory capacitors is possible, which substantially extends the capacitance measuring range of the bridge both upward and downward.

The Model 35A is a 3-terminal bridge, and remote measurements via coaxial cables are possible.

The directly calibrated test signal is continuously adjustable from 100 KHz to 50 MHz in 9 ranges of approximately 1 octave each. The test signal level is continuously adjustable from 5 millivolts to 25 millivolts and

is automatically leveled over the complete frequency range.

The tuned detector input circuits are ganged to the test oscillator frequency control so that separate detector tuning is not required.

Once adjusted to the desired value, the test level remains constant regardless of the balance condition of the bridge.

The Model 35A is equipped for both dual external dc bias and single internal dc bias. Externally supplied bias voltages appear between HI post and ground and/or the LO post and ground, independently of each other.

The internally supplied dc bias appears between HI and LO posts only, and is continuously adjustable from 0 to 100 V.

Front panel jacks are provided for monitoring both internal bias voltage and current.

The Model 35A is completely self-contained, including bridge circuitry, oscillator, and detector, and is packaged for bench operation.

SPECIFICATIONS

Frequency Range:
Frequency: 100 kHz - 50MHz
Accuracy: ±2%

Test Level Range:
10-30 millivolts rms

Bias:
Internal: 0 - 100 volts, 6 mA max.
External: 0 - 200 volts, 10 mA max.

Power Requirements:
115/230 V, 50/60 Hz, 75 W

Physical Characteristics:
Weight: 43 pounds
Size: 11½" h x 19½" w x 12¾" d

Capacitance Measurement, Direct:
Capacitance Range: 20 - 1000 pF
C Accuracy: $\pm(0.5 + f/50)\%$ ±0.3 pF
Q Range: 5 - 10,000
Q Accuracy: $\pm(10)\%$ $\pm(Q/10^3)\%$ — $(QfC/5 \times 10^6)\%$
C is capacitance of test in pF
f is test frequency in MHz

Capacitance Measurement, Indirect:

Cap. Range	*C Accuracy*	*Q Range*	*Q Accuracy*
0.002 - 2 pF	±10%	—	—
2 - 20 pF	$(2 + 20/C_x)\%$	0.5 - 5000	$\pm10\%$ $\pm(2Q/10^3)\%$
1000 pf - 0.25 μF	±5%	—	—

Inductance Measurement, Indirect:
Inductance Range: 0.1 μH - 100 mH
L Accuracy: ±5% (2% using frequency counter)
Q Range: 5 - 500
Q Accuracy: ±10%

Resistance Measurement, Indirect:
Resistance Range: 5 ohms - 500 megohms
R Accuracy: $\pm10\%$ $\pm(Q/10^3)\%$

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MICROWAVE POWER DETECTORS

MODEL 41-4 SERIES

With the addition of the new Model 41-4D to the group of Power Detectors for use with the Model 42A and 42AD RF Microwattmeters, accurate measurement of power is now possible from 200 kHz up to 18 GHz, with excellent VSWR and frequency response. The user may select the unit or units best suited to his particular needs. Three of these Detectors have input impedances of 50 Ω, and offer reliable measurements up to frequencies of 7, 12.4, or 18 GHz. The other Detector, designed especially for CATV applications, has an input impedance of 75 Ω, with an upper frequency limit of 1 GHz.

Input VSWR on all units is maintained within low limits throughout the frequency band. Input connectors are normally precision type N, although APC-7 connectors can be supplied to order.

SPECIFICATIONS

	41-4A	41-4B	41-4C	41-4D
Input Impedance	50 Ω	50 Ω	75 Ω	50 Ω
Frequency Range	200 kHz-7 GHz	200 kHz-12.4 GHz	200 kHz-1 GHz	12-18 GHz
VSWR	<1.4	<1.5	<1.3	<1.5

BOONTON ELECTRONICS CORPORATION
PARSIPPANY, NEW JERSEY

Model 42A Series RF Microwattmeters

Programmable, Solid State, RF Microwattmeters Analog and Digital Readout

Analog Model 42A

Digital Model 42AD

STANDARD FEATURES

- ☐ Measures 1 nW to 10 mW (-60 to +10 dBm)
- ☐ Covers 200 kHz to 12.4 GHz
- ☐ Temperature stability 0.007 dB/°C, typical
- ☐ No zeroing above 1 μW (drift <1 nW/h.)
- ☐ Overload rating 0.3 Watts cw
- ☐ Fast, high-level dc output
- ☐ All ranges and functions programmable
- ☐ BCD data outputs and commands (Model 42AD)

OPTIONAL FEATURES

- ☐ Logic-level programming
- ☐ Autoranging (Model 42AD)
- ☐ Digital dBm readout (Model 42AD)
- ☐ 75Ω power detector for CATV applications

INTRODUCTION

The Models 42A and 42AD are exceptionally sensitive high-frequency power meters that have overcome many of the limitations of instruments employing thermal elements for power detection. The one power detector head covers more than the dynamic range of three thermocouple heads, and in addition it measures 15 dB lower power levels. Drift problems are virtually eliminated, and continuous overloads of up to 0.3 W cw are tolerated without damage to the detector or change in its characteristics.

The practical accuracy of the combined instrument and power detector is specified. This is a true long-term absolute accuracy statment which allows the instrument to be used without frequent calibration checks.

Solid-state switches activate each power range. This results in completely reliable local, remote, or automatic ranging.

Programmed-converter applications are satisfied by the high-level dc output which is standard on all models.

Computer-controlled test-systems, printers, and comparators may easily be interfaced using the BCD outputs which are standard on the Model 42AD.

Flat frequency response over typical swept-frequency band widths combined with a linear dc output in terms of power, make the digital Model 42AD-09 a useful tool in swept-frequency testing of microwave subsystems and components.

Since no adjustments are made on the detector head when performing a measurement, it may be located up to hundreds of feet away from the main unit. This allows remote power monitoring in dangerous or difficult-to-reach locations.

Important input and accuracy specificatons are shown on a reference plate attached to the top of the instrument case and recalibration information is printed inside the top cover.

The half-rack package is only 5.2 inches high. Single or dual rack adapters are available for combination of the 42 series into 19-inch rack systems.

STANDARD FEATURES

Accuracy:
The two-term accuracy statement is broken down into the scale linearity of the instrument in percent of full scale, which is constant and independent of frequency, and the absolute calibration error in dB which varies with frequency.
An individual dB vs frequency correction curve is attached to each power detector as supplied.

Power Detectors:
Two 50Ω power detector heads are available. Each has a frequency range that starts at a low 200 kHz to cover the MF band. One detector has a frequency range up to 7 GHz and the other to 12.4 GHz. The 7 GHz head is available at lower cost.
Input VSWR is maintained within low limits throughout the frequency band, equalling that of thermal type detectors.
Additionally, a 75Ω detector head with the same power range may be specified. It has a 200 kHz to 1 GHz frequency range specially designed for CATV applications.
Input connectors are precision type N. Detectors can be supplied with 7 mm APC-7 connectors to special order.

Power Sensitivity and Range:
The 42 series measures from an exceptionally low 1 nW (-60 dBm) to 10 mW (+10 dBm). This unique range opens new applications for low power measurement such as field alignment of microwave antennas. The wide 70 dB dynamic range in one detector head removes the need to change heads and reduces the need for attenuators.

Stability:
Zero drift in the Model 42 series is less than 1 nW per hour. As a result, the requirement for frequent zero adjustment is vastly reduced. No zero adjustment is required for measurements on the 1μW (-30 dBm) range or above. On the two lowest ranges the zero setting needs only infrequent checking during the course of operation, a point of major importance where rapid, repetitive measurements or long-term monitoring is involved.
Temperature drift is typically no more than 0.007 dB per °C. This is inherent in the design and is achieved without the need for compensating loops or components.

Waveform Response:
True average power is indicated within specified accuracy at all levels. Below -20 dBm input waveform does not deteriorate accuracy (except for extremely low duty-cycle pulses). Above -20 dBm input waveform must be considered if it deviates severely from sinusoidal. At all power levels Boonton's unique full wave detector circuit eliminates asymmetry as a source of error (odd harmonic distortion).

Chopper Circuit:
A unique sampling circuit reduces even further the already low noise contributed by the mechanical chopper, greatly reducing the effects of change in chopper performance that could occur with the passage of time.

DC Output:
The linear dc output voltage of the Model 42AD is directly proportional to input power. It may be used for driving a plotter or recorder, for connection to an oscilloscope for swept-frequency measurements, or for system interface.
The dc output voltage of the Model 42A is proportional to the square root of the input power (proportional to applied voltage). It may be used with suitably scaled ancillary equipment.

BCD Outputs:
BCD outputs are standard on the Model 42AD. They are TTL compatible and use standard positive logic.

Programming:
Input-range programming by external contact closure or PNP transistor switch to ground is standard on all models. When options add other functions, these are also programmable.

OPTIONAL FEATURES

Logic-Level Programming:
Logic-level programming accepts standard positive TTL inputs with individual lines controlling ranges and any option-added functions. This plug-in option is available on all models.

Autoranging:
When autoranging is specified (Model 42AD only), the digits, decimal point, and units are quickly and automatically displayed creating the ultimate in no-involvement rf power measurement. Up ranging occurs at 5 per cent above full scale and down-ranging at 10 per cent of full scale.
Autoranging may be selected remotely or at the front panel.

Digital dBm Readout:
A logarithmic operating mode allows digital indication of power in terms of dBm. The complete number of dBm from +10 to -60 is digitized making it unnecessary to refer to the range switch position when taking a reading.

VERSIONS

Analog Readout Model 42A:
The large mirrored-scale panel meter has two scales. One reads from 1 to 10 in absolute power units and the other from 0 to -11 in dBm. Optionally, the meter may be ordered with the power scale uppermost.

Digital Readout Model 42AD:
The digital version has a 3-digit readout plus "1" for 5 per cent overrange. It employs nixie-type display tubes for bright, easy-to-read characters, and includes BCD outputs and commands as standard. Normally the readout is free-running with a display period of 250 ms, but it may be externally triggered to give BCD outputs every 10 ms if visual readings are not required.
An unusual feature allows the zero to be quickly and easily adjusted using the vertical edge-meter to the right of the display. The meter is calibrated in dBm, and is additionally useful for peaking and nulling.

SPECIFICATIONS

ANALOG READOUT VERSION (MODEL 42A)

Power Range: 1 nW (-60 dBm) to 10 mW (+10 dBm)

Full Scale Ranges: 10 nW, 100 nW, 1μW, 10μW, 100μW, 1 mW and 10 mW (-50 to +10 dBm)

Maximum Safe Overload: 300 mW cw (+25 dBm)

Frequency Range: 200 kHz to 12.4 GHz with 41-4B Detector, 200 kHz to 7 GHz with 41-4A Detector, 200 kHz to 1 GHz with 41-4C Detector

Accuracy:

	±0.5% fs plus		
100 nW fs to 10 mW fs ranges (-40 dBm fs to +10 dBm fs)	±0.2 dB	±0.3 dB	±0.4 dB
	200 kHz	4 GHz	8.2 GHz 12.4 GHz

10 nW fs range (–50 dBm fs)	±1% fs plus		
	±0.4 dB	±0.6 dB	±0.8 dB
	200 kHz	4 GHz	8.2 GHz 12.4 GHz

Meter: 4½ inch taut band. Two scales, dBm and power

Top Scale, (dBm) Red: –11 to 0 dBm with 0.2 dB or 0.5 dB subdivisions

Bottom Scale, (power) Black: 1 to 10 with 1 per cent or 2 per cent subdivisions

Meter Unrest: 10 nW fs (–50 dBm) range only; above 4 nW ±1 per cent fs max., 1 to 4 nW ±2 per cent fs max.

Zero Drift: 1 nW/hr. max. on 10 nW range

Temperature Influence: In accordance with ANSI (ASA) Spec. 39.7

Temperature Range	Influence*	
	Inst.	Detector
Reference 21°C to 25°C	0	0
Normal 18°C to 30°C	0	±0.1 dB
Severe 10°C to 40°C	±0.2 dB	±0.2 dB

*Add to accuracy specification

RFI: No detectable radiated or conducted leakage from the instrument or power detector.

Waveform Response: Input level 1 nW to 10 μW; true average power. Input level above 10 μW; average power of sine wave (true rms response changing to peak response).

DC Output: 0 to +10 V on each range, proportional to the square root of input power. Source resistance 9kΩ. 1 mA max into 1kΩ load.

Response Time: Full scale input step function response time.

Ranges	Speed
10 mW fs to 10 μW fs	100 ms
1 μW fs to 10 nW fs	1 s

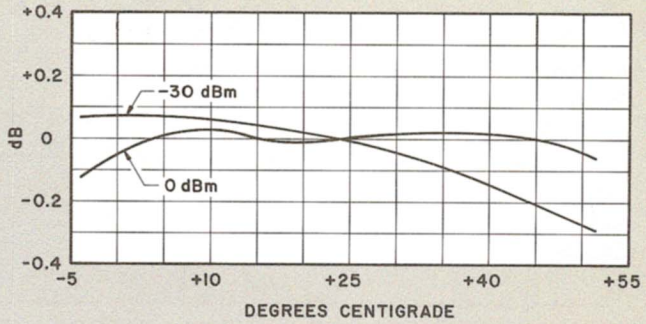
Programming: External closure or PNP transistor to ground selects each range. Source, –12V behind 15kΩ. Speed, 100 ms per range change. (Logic-level programming optional.)

Power: 117 or 235V ±10 per cent, 50-400 Hz 8 W

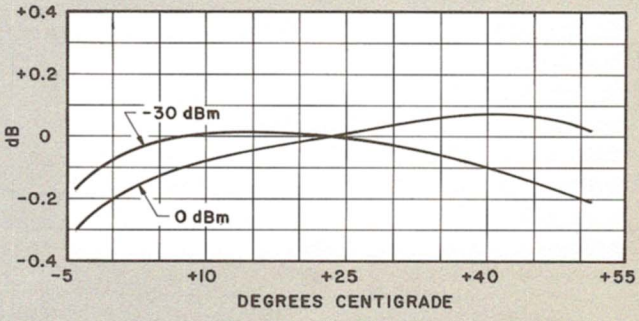
Dimensions: 5.2" (132 mm) high (without feet), 8.3" (211 mm) wide (without handle), 12.0" (305 mm) deep

Weight: Net, 8 lbs (3.7 kg) (with detector and cable). Shipping, 11 lbs. (5.0 kg)

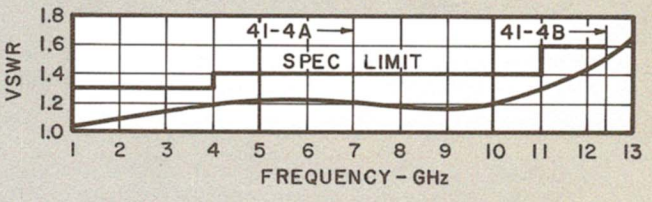
Accessories Furnished: 5 ft. power detector cable Model 41-2A. Longer cables to special order.



Typical Temperature Characteristic of 41-4A and 41-4B Power Detectors



Typical Temperature Characteristic of Instrument and 41-4A or 41-4B Power Detector



Typical VSWR Characteristic of 41-4A and 41-4B Power Detectors

Power Detectors: Input connector, Precision Type N* . Output connector, to fit 41-2A cable. Dimensions, 1.5" (38 mm) dia.; 3.5" (90 mm) length. Calibration curve attached.

Model	41-4A	41-4B	41-4C
Input Impedance	50 Ω	50 Ω	75 Ω
Freq Range	200 kHz - 7 GHz	200 kHz - 12.4 GHz	200 kHz - 1 GHz
VSWR	<1.3 to 4 GHz <1.4 to 7 GHz	<1.3 to 4 GHz <1.4 to 11 GHz <1.6 to 12.4 GHz	<1.3 to 1 GHz

*Power detectors with APC-7 connectors can be supplied to special order

DIGITAL READOUT VERSION (MODEL 42AD)

Accuracy:

Power:

0.1 μW fs to 10 mW fs ranges

±0.1% fs plus		
±0.2 dB	±0.3 dB	±0.4 dB

200 kHz 4 GHz 8.2 GHz 12.4 GHz

10 nW fs range

±1% fs plus		
±0.4 dB	±0.5 dB	±0.6 dB

200 kHz 4 GHz 8.2 GHz 12.4 GHz

dBm (if option-09 is specified):

-40 dBm fs to +10 dBm fs ranges

0.02 x △ dB from fs, plus		
±0.2 dB	±0.3 dB	±0.4 dB

200 kHz 4 GHz 8.2 GHz 12.4 GHz

-50 dBm fs range

0.04 x △ dB from fs, plus		
±0.4 dB	±0.5 dB	±0.6 dB

200 kHz 4 GHz 8.2 GHz 12.4 GHz

Display: Nixie-type, non-blinking, 3 digits +1 for 5 per cent overrange. Blanked for overrange and below 10 per cent fs. Vertically-mounted edge-meter to right of display is calibrated dBm, accuracy not specified.

Display Period: 250 ms

Encode Period: 10 ms

Data Outputs: 1-2-4-8 binary coded decimal information. 1-2-4 binary coded range information. Overrange, underrange, encode complete.

Commands: Encode hold, encode trigger, manual disable, auto enable (-01 option) and dBm enable (-09 option).

Logic Levels: Logic 1 ≥ 3V; logic 0 ≤ 0.3V TTL compatible.

DC Output: 0 to 10 V proportional to rf input power. Source resistance 9 kΩ. Will deliver 1 mA to 1kΩ load (1 V); accuracy as previously specified for meter indication.

Power: 117 or 235V ± 10 per cent, 50 to 400 Hz, 10 W.

Weight: Net, 9.5 lbs (4.4 kg) (with detector and cable). Shipping, 12.5 lbs (5.7 kg).

All other specifications are the same as Model 42A. Options as specified.

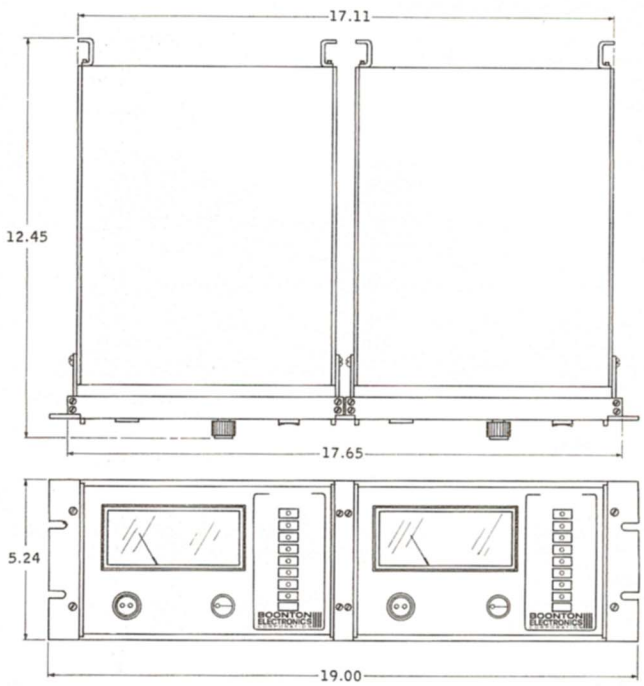
OPTIONS

Model Suffix	
Model 42A	
-02	Logic-level programming option; 8 line logic-level input selects range. TTL compatible.
-08	Rear signal-input option.
-11	Reverse scale option; dBm as bottom scale on meter.
Model 42AD	
-01	Autoranging option; digits, decimal points, and units are automatically displayed. Allows programmable and manual selection of autorange.
-02	Logic-level programming option; 8 line logic-level input selects range. Additional logic-level lines select dBm or autorange if optioned. TTL compatible.
-08	Rear signal-input option.
-09	dBm / power readout option; allows programmable and manual selection of either dBm or power to be read on the digital display. Logic-level outputs indicate power and ± dBm.

RACK MOUNTING KITS

Rack-mounting kit (mounts left or right) 92-1A

Dual rack-mounting kit 92-1B



Model 92-1B Dual Rack Mounting Kit is illustrated. Model 92-1A Kit is similar except that a blank half-rack panel is supplied instead of one of the two mounting frames.

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Printed in U.S.A. 5M 1-72 RP

BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY

Model 63H Inductance Bridge

Precise Measurements of Inductance to Low Values Over a Frequency Range from 5 KHz to 500 KHz

- Inductance Range, 0 to 110 mH; Basic Accuracy, 0.25%; Basic Resolution, 0.01%
- Resistance Range, 0 to 11 K ohms; Maximum Resolution, 0.0002 ohm
- Test signal continuously adjustable from 5 KHz to 500 KHz
- Maximum open-circuit test signal level, 3 V
- Test current independent of balance condition of bridge
- Completely self-contained, including test signal oscillator and null detector
- Outstanding stability
- No false or sliding nulls
- Simple, convenient operation
- Valuable for laboratory use, production testing, or for quality assurance inspection

Introduction

The Model 63H is a highly advanced bridge which provides direct reading measurements of series inductance down to low values with fractional percentage accuracy, and under an unusually broad range of test conditions. The instrument also makes direct reading measurements of series resistance.

Beyond its use in the basic research or development laboratory, the Model 63H, with its simplicity of operation and excellent stability, finds widespread application in quality assurance and production test functions.

The instrument is completely self-contained, including bridge circuitry, variable frequency test oscillator, detector, and null indicator. It is packaged as a single, compact bench unit. Built on a 19 inch chassis, it can be installed in a standard relay rack when the cabinet is removed.

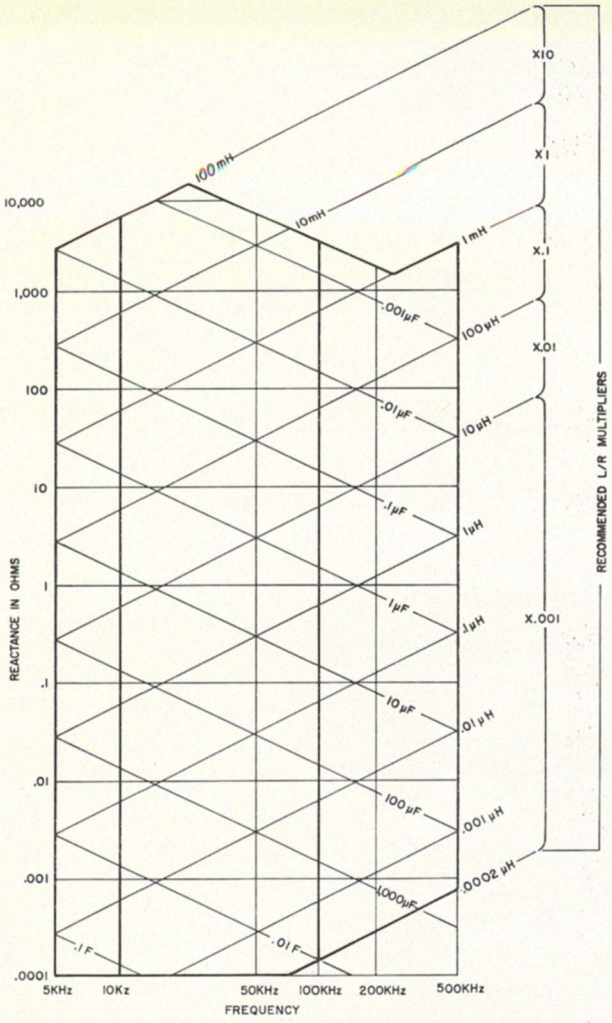

Figure 1. Diagram of the operational range of the Model 63H

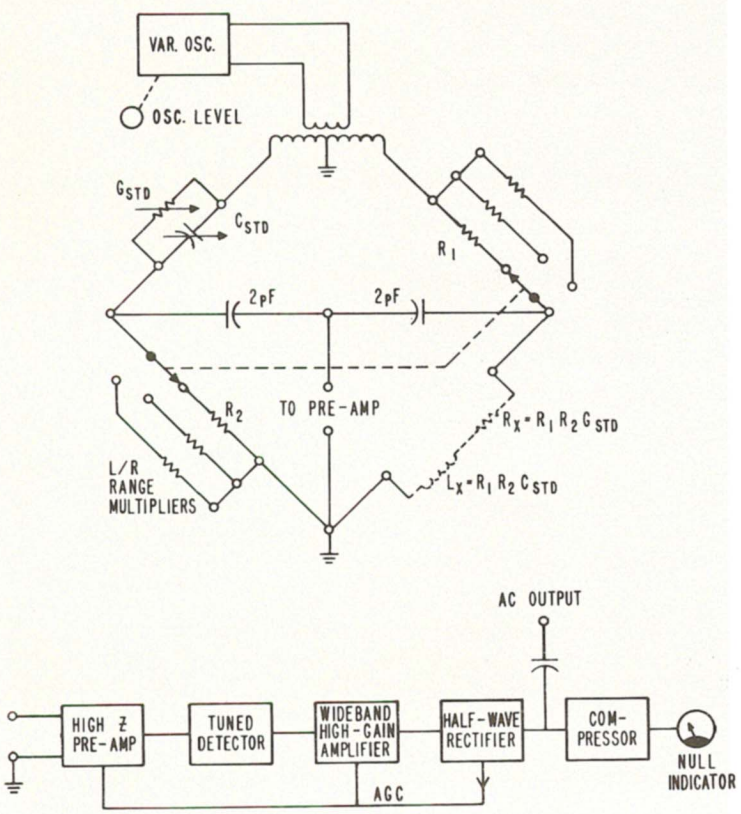

Figure 2. Simplified schematic of the Model 63H

Bridge Circuit

The Model 63H embodies a modified Maxwell circuit (see simplified schematic of Figure 2). The test signal generator and null detector are coupled to the bridge by a technique which constitutes a particularly practical approach to the design of a Maxwell circuit whose capabilities for precision measurements extend over wide ranges of inductance and test frequencies. The two sides of the bridge are driven 180 degrees out of phase by a well balanced low impedance transformer. This permits detection of the balance condition by coupling the detector to the high corners of the bridge through two small, carefully balanced capacitors.

It is characteristic of this bridge circuit that the inductance and resistance arms act independently of each other. By eliminating interaction between the two arms the annoyance and ambiguity of false or sliding nulls is avoided.

Since the bridge is of the non-resonant type, the precision of frequency setting is not critical to the accuracy of measurement. Bridge accuracy is determined primarily by the balancing controls, the precision resistors in the range selector, and the silvered mica capacitors comprising the inductance decade. All of these components are adjusted to better than 0.1% accuracy.

Great care has been taken in both the electrical and mechanical design of the Model 63H to compensate or eliminate the sources of residual error that commonly restrict the acuracy of measurement of bridges operating at these frequencies, providing true "state of the art" precision and stability. Inductance drift in the instrument is typically less than 0.01% after 90 minute warm up. The excellent scale readability of the Model 63H allows full advantage to be taken of the instrument's capability for high precision and resolution. The combination of the outer "counter dial" and inner 20-to-1 vernier (see Figure 3) displays any inductance measuring range across a scale effectively more than 200 inches long. This dial arrangement also enables convenient rapid scanning to locate the null, as well as accurate fine adjustment to achieve precise balance.

Null Detector

As shown in figure 2, the null detector is coupled to the bridge at the high corners through two balanced capacitors. The untuned high impedance preamplifier prevents bridge loading and contributes to the overall system sensitivity. Adjustment of the tuned detector is independent of the test signal generator control.

Frequency response of the final wide band detector amplifier is essentially flat over the total frequency range of the instrument. It has a maximum gain of 65 db giving a total detector system gain of approximately 105 db.

Output from the wide band amplifier is passed through a half wave rectifier, compressed, and then metered. System sensitivity is further enhanced by use of a 50 microampere taut band meter for null indication.

The ac component of the rectified output from the wide band amplifier is also available at a rear

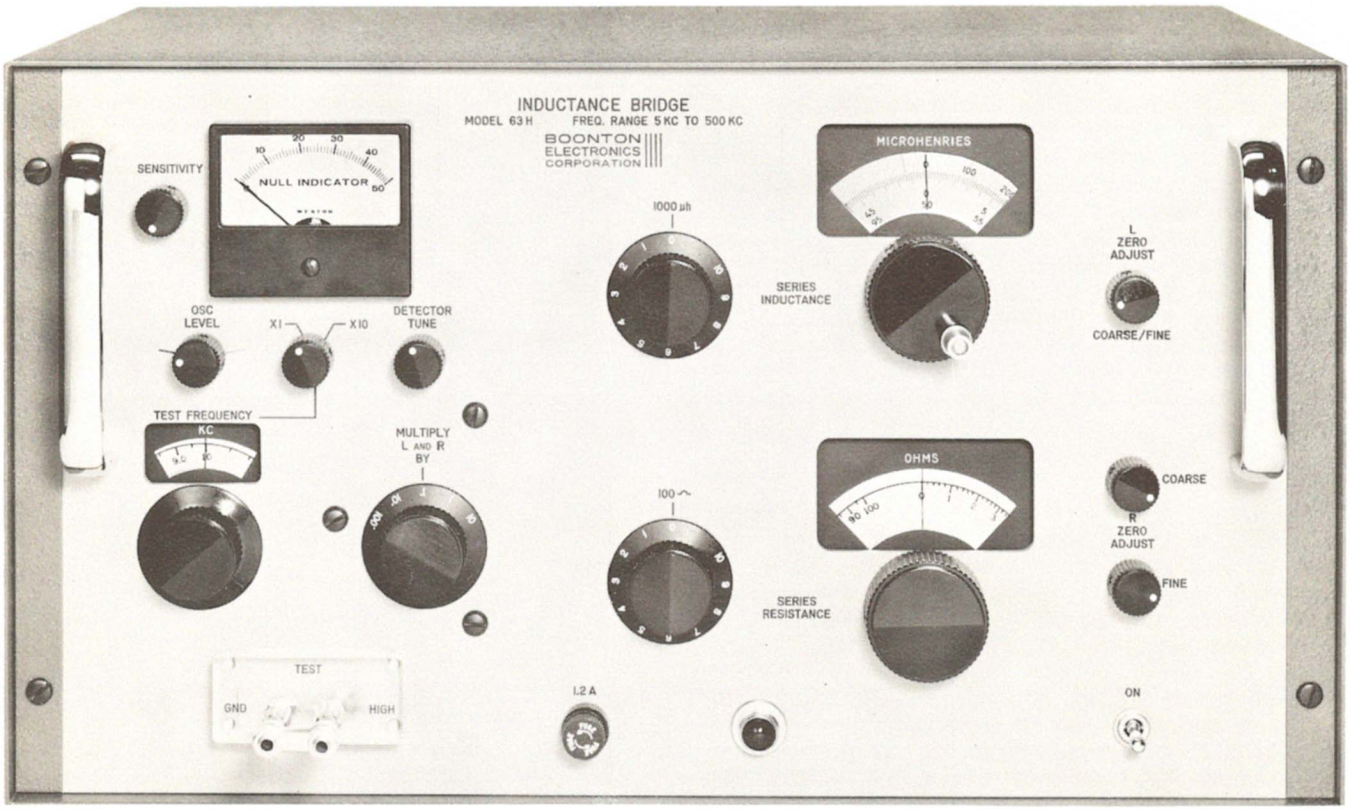

Figure 3. Front panel view of the Model 63H

jack for connection of an oscilloscope or other ac indicator.

Test Signal

The internal test signal oscillator is continuously adjustable in frequency from 5 KHz to 500 KHz. Accuracy of frequency setting is 3%. As stated above, in this bridge circuit precision of test frequency setting is not critical to the accuracy of measurement. In the rare circumstance in which more accurate frequency adjustment is required, the test signal may be monitored with a counter and set more precisely.

The test signal level is continuously adjustable by means of a front panel control and may be monitored at the test terminals with a high impedance electronic voltmeter. Maximum open circuit level is 3 volts. Test current may also be monitored by means of a "clamp-on" type probe and a senstitive ac voltmeter.

The test current is independent of the balance condition of the bridge, a fact of considerable importance in applications involving such components as ferrite cores, since their permeability varies with the level of excitation current. Were the test current to change from the known level during balancing, meaningful measurements would be impossible.

A dc current may be superimposed on the test signal if desired.

APPLICATIONS

General

The Model 63H, with its wide range of test provisions, high accuracy, and excellent resolution, is valuable for a great variety of research and development applications. Moreover, since balancing is such a simple, rapid process, the instrument is also used widely in production and quality assurance.

Inductance and Loss

There is a distinct advantage in measuring the inductive characteristics of a component at or near the frequencies at which it is to be used rather than measuring at a low frequency and attempting to extrapolate. Such phenomena as skin effect, distributed capacitance, changing permeability, and loss factors are not detectable at low frequencies (1 KHz for example). At the frequencies over which the Model 63H operates, however, these effects can be accurately measured, and operating characteristics at higher frequencies may be realistically computed. This applies not only to inductors, but particularly to such components as resistors, (even so-called "non-inductive" types), switches, connectors and connection systems, terminations, and other sources of residual inductance.

Temperature Coefficients

The accuracy, high resolution, and excellent stability of the Model 63H make it especially valuable for temperature coefficient studies. The lead inductance of the connecting cables can be "zeroed out" so that the specimen can be located in an environmental chamber during the tests without incurring significant error (so long as reasonable care is taken to control the effects of lead capacitance or changes in lead capacitance). These same features suit the Model 63H for monitoring the progress of temperature and humidity cycling of inductors, and permit accurate observation of retrace during successive stabilizing cycles until the required characteristics are achieved.

Transformers

The Model 63H is particularly well suited for a number of test involving transformers, especially rf, if, and broad band types. Measurements of primary inductance, leakage inductance, mutual inductance, and coupling coefficient may readily be made. Since the Q of these devices is often low, the ability of the Model 63H to measure small values of inductance, plus its high frequency capability permit measurements that are difficult, if not impossible, with other instruments. In addition the high resolution of the Model 63H enables detection of shorted turns in these transformers, even when the defect involves only a few turns.

Permeability

The Model 63H provides a convenient and accurate means for determining the permeability and Q of toroidal cores. The high resolution of the instrument permits detection of small permeability differentials resulting from variations in processing and design, and this coupled with excellent stability also allows reliable, reproducible measurements of temperature coefficient.

Permeability Test Fixture

The Boonton Electronics Model 63-11B Mu Jig is an accessory test fixture specifically designed for measurements on toroidal cores. It consists essentially of a seven-turn coil whose windings may be opened to accept the test specimen. It may be either plugged directly into the test terminals of the instrument or operated at a distance from the bridge (as long as reasonable care is taken to minimize the capacitance effect of the connecting cable). The measured inductance and series resistance, first with and then without the sample core, are submitted to simple, well established computation, to yield the permeability or Q. Of particular importance where ferrite cores are involved is the fact that the test current through the Mu Jig (and hence the permeability value) does not vary as the bridge is brought to balance.

SPECIFICATIONS

Inductance Measuring Range: 0 to 110 mH in 5 steps as follows:

Multiplier	Inductance Range	Resolution of Inductance Reading
10.0	0 to 110 mH	.01% +2.0 μH
1.0	0 to 11 mH	.01% +0.2 μH
0.1	0 to 1100 μH	.01% +0.02 μH
0.01	0 to 110 μH	.01% +0.002 μH
0.001	0 to 11 μH	.01% +0.0002 μH

Inductance Measuring Accuracy: $0.25\% + \frac{300}{C}\% + 0.0002\ \mu H$

where C is the resonating capacitance in pF of the test inductance at the frequency of test.

Series Resistance Measuring Range: 0.0002 ohm to 11K ohms in five ranges as follows:

Multiplier	Series Resistance Range	Accuracy
10.0	0 to 11K Ω	$3\% + \frac{Q}{25}\% + 5\ \Omega$
1.0	0 to 1,100.0 Ω	$3\% + \frac{Q}{25}\% + 0.5\ \Omega$
0.1	0 to 110.0 Ω	$3\% + \frac{Q}{25}\% + 0.05\ \Omega$
0.01	0 to 11.0 Ω	$3\% + \frac{Q}{25}\% + 0.005\ \Omega$
0.001	0 to 1.1 Ω	$3\% + \frac{Q}{25}\% + 0.001\ \Omega$

Frequency Range: 5 KHz to 500 KHz with internal oscillator and detector.

Frequency Accuracy: $\pm 3\%$

Frequency Stability: Approximately 0.5% after 30 minute warm-up.

Max. AC Test Level: Approximately 3.0 V, RMS, open circuit.

Power Requirements: 105 to 125V, 50-60 Hz, 60 watts, or 210 to 250 volt, 50-60 Hz, as specified.

Size: 19¼" w x 10¾" h x 11¼" d; case mounted. (Also available for 19-inch rack mounting.) Weight, approx. 35 lbs.

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BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY

Models 63L and 63M Variable Frequency Inductance Bridges

Accurate, Convenient Measurement of Series Inductance Over Wide Ranges of Test Value and Frequency

	Model 63L	Model 63M
Test Frequency	400 Hz to 40 KHz	1 KHz to 100 KHz
Inductance Range	0 to 11 H	0 to 1.1 H
Inductance Resolution	0.02 uH	0.002 uH
Resistance Range	0.01 Ω to 110 KΩ	0.002 Ω to 110 KΩ

- Basic Inductance Accuracy, 0.25%
- No false or sliding nulls
- Test current independent of balance conditions of bridge
- Maximum open-circuit test level 5.5V
- Outstanding stability

- Completely self-contained, including bridge circuit, oscillator, detector, and null indicator.

Introduction

The Models 63L and 63M are highly advanced bridges which provide direct reading measurements of series inductance down to low values with fractional percentage accuracies, and over unusually broad ranges of test frequency and level. They also make direct reading measurements of series resistance.

With their simplicity of operation and excellent stability, these bridges find widespread application in quality assurance and production test functions, in addition to use in the basic research or development laboratory.

The instruments are completely self-contained, including bridge circuitry, variable frequency test oscillator, detector, and null indicator. They are packaged as compact bench units, and, with the dust cover removed, can be installed in a standard 19-inch rack.

Bridge Circuit

The Models 63L and 63M embody a modified Maxwell circuit (see simplified schematic of Figure 2). The test signal generator and null detector are coupled to the bridge by a technique which constitutes a particularly practical approach to the design of a Maxwell circuit whose capabilities for precision measurement extend over wide ranges of inductance and test frequencies. The two sides of the bridge are driven 180 degrees out of phase by a balanced low impedance transformer. This permits detection of the balance condition by coupling the detector to the high corners of the bridge through two small, balanced capacitors.

It is characteristic of this bridge circuit that the inductance and resistance arms act independently of each other. By eliminating interaction between the two arms the annoyance and ambiguity of false and sliding nulls is avoided.

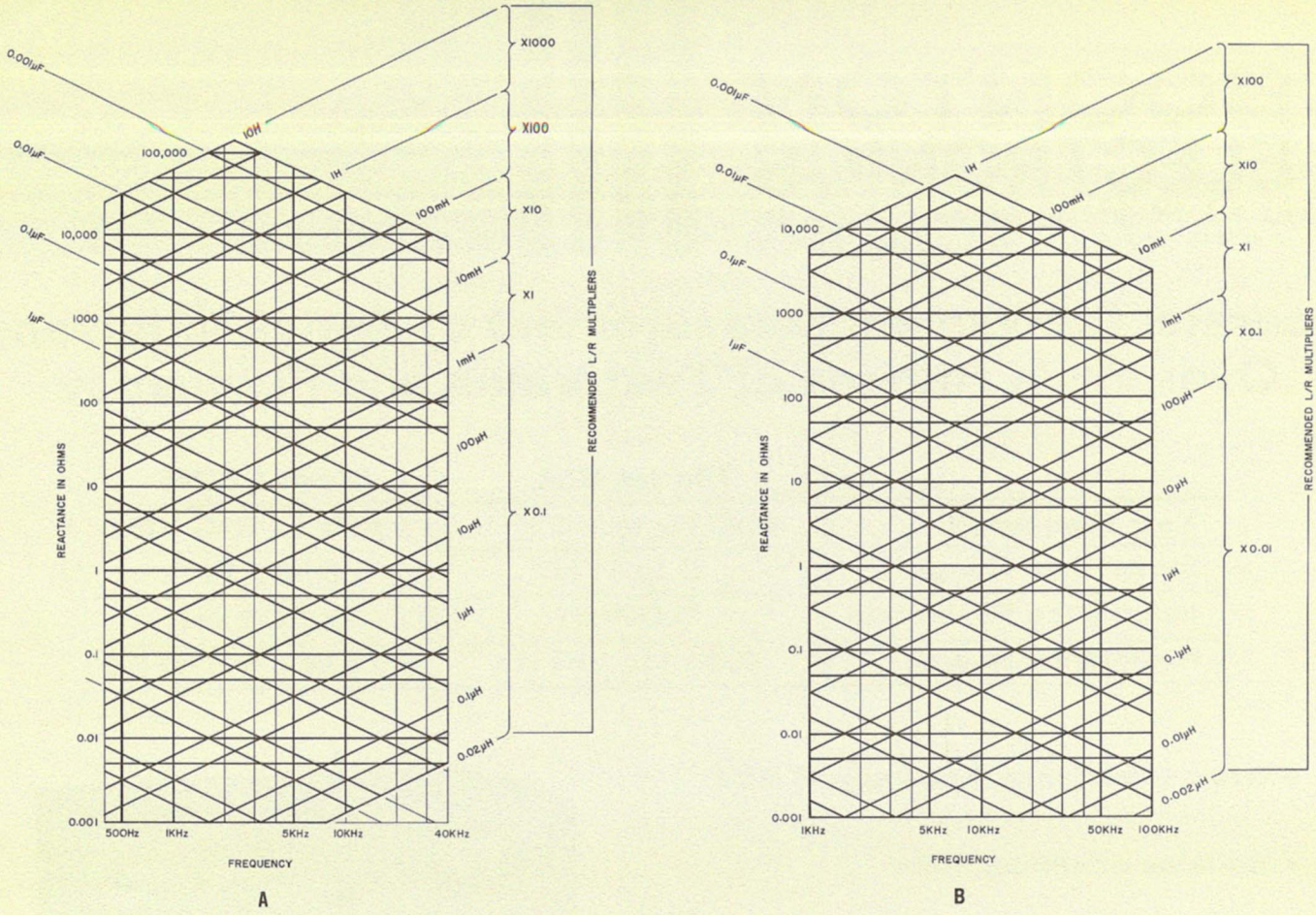

Figure 1. Diagrams of the operational range of the Model 63L (A) and Model 63M (B)

Since the bridge is of the non-resonant type, the precision of frequency setting is not critical to the accuracy of measurement. Bridge accuracy is determined primarily by the balancing controls, the precision resistors in the range selector, and the silvered mica capacitors comprising the inductance decade. All of these components are adjusted to better than 0.1% accuracy.

Great care has been taken in both the electrical and mechanical design to compensate or eliminate the sources of residual error, and to obtain the greatest possible stability. Inductance drift is typically less than 0.01% after a 90 minute warm-up.

Excellent scale readability allows full advantage to be taken of the capability of these instruments for high precision and resolution. The combination of the outer "counter dial" and inner 40-to-1 vernier (see Figure 3) displays any inductance measuring range across a scale effectively more than 200 inches long. This dial arrangement also enables convenient, rapid scanning to locate the null, as well as accurate fine adjustment to achieve precise balance.

Null Detector

As shown in Figure 2, the null detector is coupled to the bridge at the high corners through two balanced capacitors. The untuned high impedance preamplifier prevents bridge loading and contributes to the overall system sensitivity.

Adjustment of the selective amplifier stage is independent of the test signal generator control so that the amplifier can be critically tuned without altering the test frequency.

Frequency response of the final wide band detector amplifier is essentially flat over the total frequency range of the instrument. It has a maximum gain of 65 db giving a total detector system gain of approximately 105 db.

Output from the wide band amplifier is passed through a half wave rectifier, compressed, and then metered. System sensitivity is further enhanced by use of a 50 microampere taut band meter for null indication.

The ac component of the rectified output from the wide band amplifier is also available at a rear jack for connection of an oscilloscope or other ac indicator.

Test Signal

The internally supplied test signal of the Model 63L is continuously adjustable from 400 Hz to 40 KHz, and of the Model 63M, from 1 KHz to 100 KHz. In both instruments, test frequency is indicated directly on the front panel, and can be set with an accuracy of 3%. As stated above, in this bridge circuit precision of test frequency setting is not critical to the accuracy of measurement. In the rare circumstance in which more accurate frequency adjustment is required, the test signal may be monitored with a counter and set more precisely.

The test signal level is continuously adjustable by means of a front panel control and may be monitored at the test terminals with a high impedance electronic voltmeter. Maximum open circuit level in both instruments is 5.5 volts. Test current may also be monitored by means of a "clamp-on" type probe and a sensitive voltmeter.

The test current is independent of the balance condition of the bridge, a fact of considerable importance in applications

involving such components as ferrite cores, since their permeability varies with the level of excitation current. Were the test current to change from the known level during balancing, meaningful measurements would be impossible.

A direct current may be superimposed on the test signal if desired. The maximum allowable dc value depends on range, but does not exceed 150 milliamperes.

APPLICATIONS

General

The wide range of measuring capabilities, excellent resolution, and high accuracy of the Models 63L and 63M make them valuable for a great variety of inductance and loss measurements in basic research or product development. In providing test frequencies which are continuously adjustable over a 100:1 range, they offer a particularly convenient means for investigating the effects of frequency on both components and materials.

The simplicity of operation, direct, clear readout, and excellent long term stability have also brought the instruments into wide use for production test and inspection functions. Here, especially, the self-contained feature of the Models 63L and 63M is a convenience, since they can be easily moved from station to station without concern for cable-connected auxiliary equipment.

Transformers

These bridges are particularly well suited for a variety of tests involving transformers. Measurement of primary inductance, leakage inductance, mutual inductance, and coupling coefficient, for example, may be readily made. In addition, the high resolution permits detection of shorted turns in transformers or coils, even when the defect involves only a few turns.

The Models 63L and 63M can measure devices having Q's down to fractional values without encountering difficulty in balancing, a fact of considerable importance in such applications as these where low Q's are often encountered.

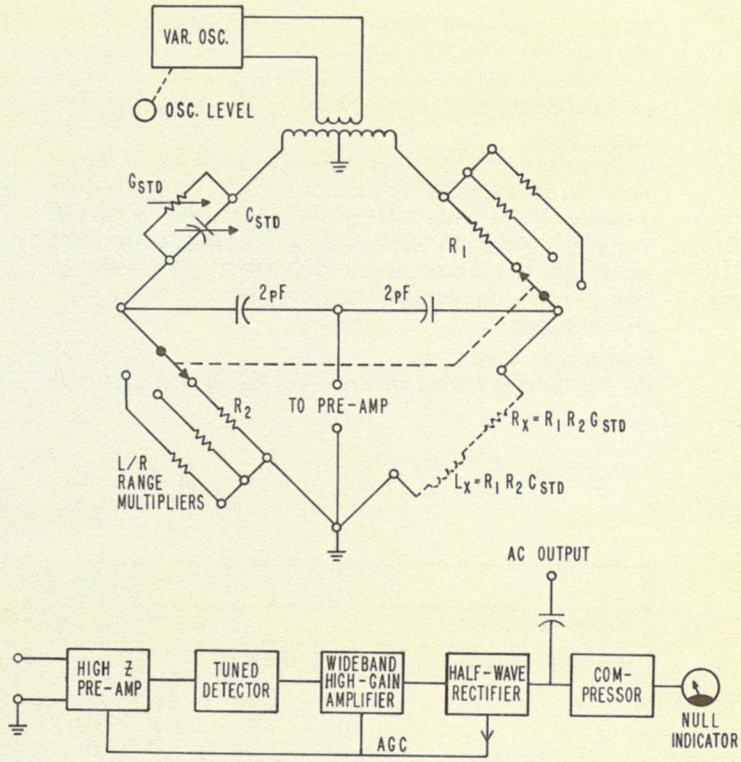

Figure 2. Simplified schematic of the Models 63L and 63M

Temperature Coefficients

The accuracy, high resolution, and excellent stability of the Models 63L and 63M make them especially valuable for temperature coefficient studies. The lead inductance of connecting cables can be "zeroed out" so that the specimen can be located in an environmental chamber during the tests without incurring significant error (as long as reasonable care is taken to control the effects of lead capacitance or changes in lead capacitance). These same features suit these instru-

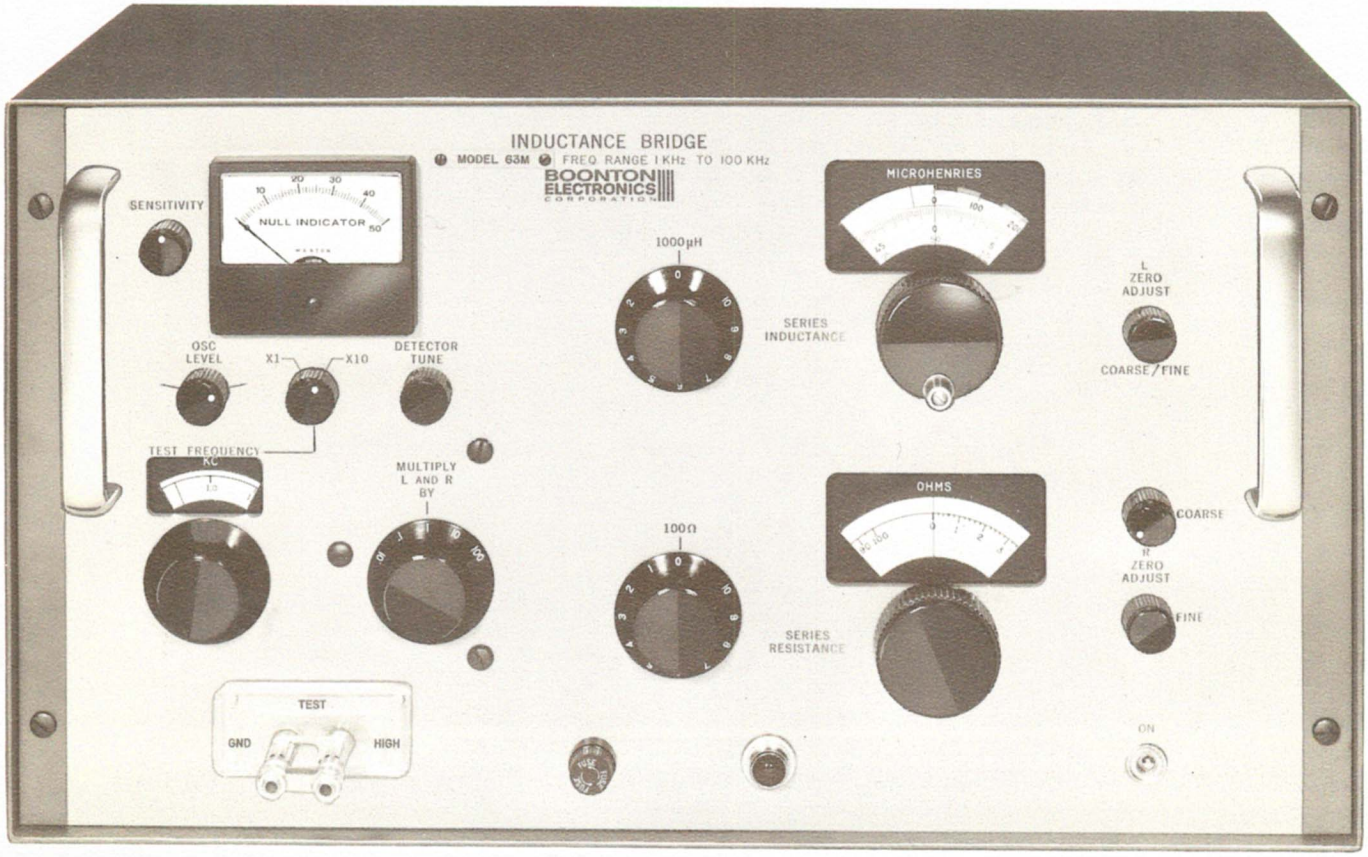

Figure 3. Front panel view of the Model 63M

ments for monitoring the progress of temperature and humidity cycling of inductors, and permit accurate observation of retrace during successive stabilizing cycles until the required characteristics are achieved.

Permeability

These bridges provide convenient and accurate means for determining the permeability and Q or toroidal cores. The high resolution of the instruments permits detection of small permeability differentials resulting from variations in processing and design, and this coupled with excellent stability also allows reliable, reproducible measurements of temperature characteristic.

Permeability Test Fixture

The Boonton Electronics Model 63-11B Mu Jig is an accessory test fixture specifically designed for measurements on toroidal cores. It consists essentially of a seven-turn coil whose windings may be opened to accept the test specimen. It may be either plugged directly into the test terminals of the inductance bridge or operated at a distance from the bridge (as long as reasonable care is taken to minimize the capacitance effect of the connecting cable).

The measured inductance and series resistance, first with and then without the sample core, are submitted to simple, well established computation, to yield the permeability and Q. Of particular importance where ferrite cores are involved is the fact that the test current through the Mu Jig (and hence the permeability value) does not vary as the bridge is brought to balance.

SPECIFICATIONS

	MODEL 63L	MODEL 63M
Inductance Range:	0 to 11 H in 5 decade steps	0 to 1.1 H in 5 decade steps
Inductance Resolution:	**MULTIPLIER / RANGE / RESOLUTION** 1000 — 0 to 11 H — 0.01% + 200 μH 100 — 0 to 1.1 H — 0.01% + 20 μH 10 — 0 to 110 mH — 0.01% + 2.0 μH 1 — 0 to 11 mH — 0.01% + 0.2 μH 0.1 — 0 to 1.1 mH — 0.01% + 0.02 μH	**MULTIPLIER / RANGE / RESOLUTION** 100 — 0 to 1.1 H — 0.01% + 20.0 μH 10 — 0 to 110 mH — 0.01% + 2.0 μH 1 — 0 to 11 mH — 0.01% + 0.2 μH 0.1 — 0 to 1100 μH — 0.01% + 0.02 μH 0.01 — 0 to 110 μH — 0.01% + 0.002 μH
Inductance Measuring Accuracy:	0.25% + 300/C% + 0.02 μH, where C is the resonating capacitance in pF of the test inductor at the frequency of test.	0.25% + 300/C% + 0.002 μH, where C is the resonating capacitance in pF of the test inductor at the frequency of test.
Series Resistance Range:	0.005 Ω to 110 KΩ in 5 decade ranges	0.002 Ω to 110 K ohms in 5 decade ranges
Series Resistance Accuracy:	**MULTIPLIER / RANGE / ACCURACY** 1000 — 0 to 110 KΩ — 3% + Q/25% + 50.0 Ω 100 — 0 to 11 KΩ — 3% + Q/25% + 5.0 Ω 10 — 0 to 1100 Ω — 3% + Q/25% + 0.5 Ω 1 — 0 to 110 Ω — 3% + Q/25% + 0.05 Ω 0.1 — 0 to 11 Ω — 3% + Q/25% + 0.005 Ω	**MULTIPLIER / RANGE / ACCURACY** 100 — 0 to 110 KΩ — 3% + Q/25% + 20.0 Ω 10 — 0 to 11 KΩ — 3% + Q/25% + 2.0 Ω 1 — 0 to 1100 Ω — 3% + Q/25% + 0.2 Ω 0.1 — 0 to 110 Ω — 3% + Q/25% + 0.02 Ω 0.01 — 0 to 11 Ω — 3% + Q/25% + 0.002 Ω
Test Frequency:	400 Hz to 40 KHz	1 KHz to 100 KHz

COMMON SPECIFICATIONS

Frequency Accuracy: ±3%

Frequency Stability: Approximately 0.5% after 30 minute warm-up

Max. AC Test Level: Approximately 5.5 V, rms, open circuit

Power Requirements: 105 to 125V, 50-60 cps, 60 watts, or 210 to 250 volt, 50-60 cps, as specified

Size: 19¼" w x 10¾" h x 11¼" d; case mounted. (Also available for 19-inch rack mounting.)
Weight, approx. 35 lbs.

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Printed in U.S.A. 5M 4/71 RP

BOONTON ELECTRONICS CORPORATION
PARSIPPANY, NEW JERSEY

Model 63-11B
Mu Jig

A Test Fixture for Convenient, Rapid Measurement of Permeability and Q of Toroidal Cores

General Description

The Model 63-11B MU JIG is a demountable test fixture which provides means for making rapid, accurate, reproducible measurements of permeability and Q of any type or size of toroidal core within the size limitations of 1.9 O.D. x 0.27″ I.D. for heights up to 0.31″, and 0.5″ I.D. for heights to 0.58″.

The MU JIG is intended for use with the Boonton Electronics 63 series Inductance Bridges and is based upon work by the National Bureau of Standards. It consists essentially of a seven turn toroidal coil whose windings may be opened to accept the test core by unplugging the top half of the fixture.

The test jig plugs directly into the terminals of the bridge or may be operated at a distance from the bridge as long as reasonable care is taken to keep lead capacitance low and **(even more important)** constant during measurements.

Theory of Operation

The MU JIG represents a considerable departure from traditional methods of measuring permeability. The conventional technique involved winding sufficient turns on the test core to approximate a uniform current sheet condition. The inductance of this coil was then compared to the calculated inductance of an equivalent air core coil (assuming a thin, current sheet) or by winding an identical coil on a core of the same geometry as the test core, but made from a low loss, unity permeability material, i.e. polystyrene, etc. The inductance of both coils was then measured and the permeability derived from the ratio. A major defect of this method lay in the fact that flux leakage was neglected, as was any departure from the assumed true current sheet condition.

A means for overcoming these sources of error was suggested by Danielson and Harrington* from whose investigations the following equations are derived:

$$\text{Permeability } (\mu) = \frac{L_m - L_o}{L_e} + 1$$

where L_m = Inductance of fixture containing test core

L_o = Inductance of fixture without core

L_e = Calculated inductance of air core (with seven turns. See formula below)

$$L_e = 0.0117\ h\ N^2 \log_{10}\left(\frac{d_2}{d_1}\right) \text{ (microhenries)}$$

where N = Number of turns (7)

h = Height of core in inches

d_1 = Inside diameter of core

d_2 = Outside diameter of core

In practical application the inductance differential of the test fixture with and without the test core is submitted to the above computation to determine the permeability. It should be noted that once L_e is derived for a given core configuration, the value will be a constant, and for that configuration subsequent permeability measurements become a simple direct process.

Core loss (Q) may be obtained from the expression:

$$Q_e = \frac{\omega (L_m - L_o)}{R_m - R_o}$$

where ω = 2π x test frequency

R_o = Resistance of fixture without core

R_m = Resistance of fixture with core in position

At 10 kHz inductance of the MU JIG is typically 0.8 μH; series resistance is 0.05 ohm. At 500 kHz inductance is 0.8 μH and series resistance is 0.10 ohm.

Used with the Model 63H Inductance Bridge tests may be made over a frequency range from 5 kHz to 500 kHz**. The Model 63H's ability to measure the lower values of inductance (down to 2×10^{-10} henry) and its excellent resolution (of the order of 0.01%) permit determination of permeability values as low as 2 or 3. At the other end of the scale, values as high as 100,000 may also be measured.

An important feature of the 63 series in this application is that the current in the test fixture is essentially independent of the balance condition of the bridge for a given range of measurement. It may be conveniently measured with a standard sensitive electronic a-c meter. Once set to a desired level, the value of excitation current is not altered by balancing the bridge during subsequent inductance and resistance measuring operations. This is particularly important for many of the ferrite materials whose permeability varies widely with the coil excitation current.

The stability of the 63 series bridges is excellent, and long term studies, such as those required for temperature coefficient determination may be made with confidence.

* See "A Technique for Reducing Errors in Permeability Measurements with Coils" B. L. Danielson and R. D. Harrington, Proc. of L. R. E., Vol. 48, No. 3; March 1960; pp 365-366.

** Tests may be made down to 1 kHz with Boonton Electronics Model 63M or 63L Inductance Bridges.

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BOONTON ELECTRONICS CORPORATION
PARSIPPANY, NEW JERSEY

Model 71A 1MHz Capacitance/Inductance Meter

Instant, Direct-Reading Measurements of Capacitance and Inductance at MHz

- **CAPACITANCE MEASUREMENTS (3-Terminal)**
  - Range: 0 to 1000 pF in 7 ranges;
  - Lowest range, 1 pF, fs
  - Resolution: ±0.25% fs
  - Basic Accuracy: ±(0.5% fs +0.5% of reading)
- **INDUCTANCE MEASUREMENTS (2-Terminal)**
  - Range: 0 to 1000 μH in 7 ranges;
  - Lowest range, 1 μH, fs
  - Resolution: ±0.25% fs
  - Basic Accuracy: ±(0.5% fs +0.5% of reading)
- **DC ANALOG OUTPUT**
  - Linearity, 0.1%
  - Provides at least 3-digit resolution on all ranges with appropriate dvm
  - Response time less than 10 ms from 0 to fs
  - Suitable for use with recorder, x-y plotter, voltage comparator, etc.
- **PARTICULARLY USEFUL FOR MEASURING SEMICONDUCTOR JUNCTION CAPACITANCE**
  - Low (15 mV) test level
  - 1 MHz crystal controlled test signal
  - Provision for dc bias up to ±200 V at 250 mA
- **MEASURES OVER WIDE RANGE OF Q VALUES; DOWN TO AS LOW AS 3 (LOWER WITH RE-ADJUSTMENT)**

- **THREE-TERMINAL ARRANGEMENT PERMITS REMOTE CAPACITANCE TESTS**
- **RACK-MOUNTING VERSION ALSO AVAILABLE**

The Model 71A provides precise, high resolution, three-terminal capacitance measurements and two-terminal inductance measurements with the speed and convenience of a vtvm. In addition the instrument offers an accurate dc analog of the test value.

The Model 71A operates by metering the quadrature current through the test while ignoring the in-phase current, so that the instrument is not susceptible to errors resulting from specimen loss over a wide range of Q values. Specified accuracy applies for Q's down to 3. Devices of lower Q (to 0.1) may be measured after proper readjustment of phase.

The measuring capabilities of the Model 71A of 0 to 1000 pF and 0 to 1000 μH are each covered in 7 ranges in a 1-3-10 sequence. Capacitance or inductance is read directly from the 6-inch mirrored scale meter.

Test signal level for capacitance measurement is fixed at 15 millivolts, permitting tests on a wide variety of solid state devices. Test level for inductance measurement is less than 1 millivolt. The highly stable test signal is crystal controlled at 1 MHz.

Dc bias up to ±200 volts at 250 mA may be applied to the test through rear panel terminals from an external supply.

The bias circuit is protected from overload by a 250 mA fuse. Resistance of the bias circuit is 7 ohms (which includes 3.5 ohms in the fuse); thus the bias voltage may be monitored at the rear terminals without interfering with measurements.

The instrument measures the capacitance of the test only. It ignores stray impedances from the "LO" post to ground; impedances from the "HI" post to ground have no significant influence on measurements above 10 pF. For values below 10 pF, the effects of capacitance from the "HI" post to ground are negated by adjustment of the "COMP ADJ." control. Thus the specimen can be connected to the terminals by coaxial cables or a remote test fixture may be used without incurring errors resulting from capacitance from either side of the test to ground. However, for larger capacitance values, the series inductance of connecting cables must be taken into consideration.

The capacitance across the test terminals contributed by an external test fixture can be zeroed out by the front panel "C ZERO" control up to approximately 7 pF. Larger amounts of capacitance (up to approximately 50 pF) can be zeroed by connecting an external balancing capacitor to the "DIFF" posts.

Beyond making possible the extension of the "C ZERO" range, the "DIFF" connections provide means for balancing the capacitance at the "TEST" terminals. By attaching another sample to the "DIFF" network, the capacitance differential between the two specimens may be measured on all but the 1 pF range. It is not possible to resolve very small differences between large capacitances by switching down to the lowest range, as in the case of a true capacitance bridge. However, it is possible to switch down one range to gain increased resolution.

The dc analog output is available at rear panel terminals in two modes. In the "DVM" mode, amplitude range is from zero to either 100 or 300 millivolts for full scale, depending on the numerics of the selected range. Thus when used in conjunction with a dvm, correct numerics are automatically maintained when switching from range to range. In the "REC" mode, the output varies from 0 to about 1.6 volts on all ranges for loads greater than 10 megohms.

Linearity of the dc analog is better than 0.1% of the reading plus 0.005% of full scale; it provides exceptionally good discrimination on a dvm. Accuracy of the dc output is better than ±0.5% when standardized with the Model 71-1A Standard Capacitor.

The dc output may be used simultaneously with the panel meter without error. In cases of rapidly changing test values, the meter may be switched off to avoid interaction resulting from a small counter emf in the moving coil and needless wear.

In providing an accurate dc analog of the continuously measured capacitance or inductance value, the Model 71A constitutes a C or L to dc converter and greatly facilitates many tests which previously could be made only by time consuming point-by-point balancing. For example, curves of such phenomena as capacitance versus voltage of voltage variable diodes may be rapidly and accurately drawn on an x-y plotter. Similarly, plots may be made of the linearity of variable capacitors or inductors, or of the tracking accuracy of a pair of variable capacitors or voltage variable diodes. Used with a dc voltage comparator, it performs high-speed go/no-go capacitance or inductance tests or provides facilities for automatic sorting or batching.

Since the dc bias voltage appears at both the "TEST" and "DIFF" terminals, it is possible to measure the tracking accuracy of two varactor diodes. Using the differential technique, the scale reads directly in pF of tracking error.

The Model 71A may also be used as the readout device for a wide variety of capacitive or inductive transducers.

SPECIFICATIONS

Capacitance Measurement (Three-Terminal):

Range, 0 to 1000 pF in 7 ranges; lowest range, 1 pF, fs
Accuracy,

$$0.5\% \text{ of reading} + \left(0.5\% + \frac{3}{Q}\%\right) \text{ fs} + 0.01 \text{ pF}$$

Resolution, 0.25%

Inductance Measurement (Two-Terminal):

Range, 0 to 1000 μH in 7 ranges; lowest range, 1 μH, fs
Accuracy,

$$0.5\% \text{ of reading} + \left(0.5\% + \frac{6}{Q}\% + \frac{L\mu H}{500}\%\right) \text{ fs} + 0.01\ \mu H$$

Resolution, 0.25%

Test Signal:

Frequency, 1 MHz, crystal controlled
Level, Capacitance measurement, 15 mV;
Inductance measurement, less than 1 mV

DC Bias:

Externally supplied bias up to ±200 V may be applied at 250 mA at rear terminals; bias circuit protected from overload by 250 mA fuse

DC Analog Output:

Level, 0 to 100 mV or 0 to 300 mV depending on full scale numerics; also >1 V fs for loads >10 MΩ
Linearity, 0.1% of reading +0.005% fs
Response Time, 10 ms with panel meter switched off

Primary Power:

117 or 234 V (±10%), 50/60 Hz: 40 watts

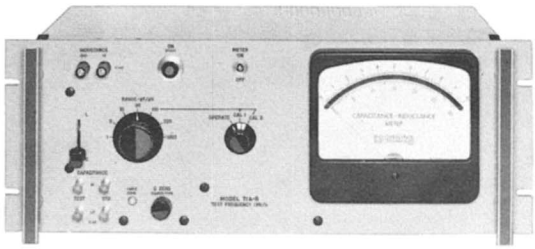
Physical Dimensions:

7¼" w x 10¼" d x 11" h; weight, 12 lbs

MODEL 71-1A STANDARD CAPACITOR

The Model 71-1A Standard Capacitor was designed specifically for calibrating the Model 71A. It is a highly compact standard adjusted to 100 pF ±0.25% against references traceable to the NBS. It provides for both high Q calibration and calibration for a Q of 3. (The Model 71-1A is built into the Model 71AR.)

MODEL 71AR RACK-MOUNTING CAPACITANCE/INDUCTANCE METER



The Model 71AR provides the performance characteristics of the Model 71A in rack-mounting form. In every respect its electrical specifications are identical to those of the bench unit. In addition, the Model 71-1A Standard Capacitor is incorporated in the Model 71AR and is switched into service by a front panel selector.

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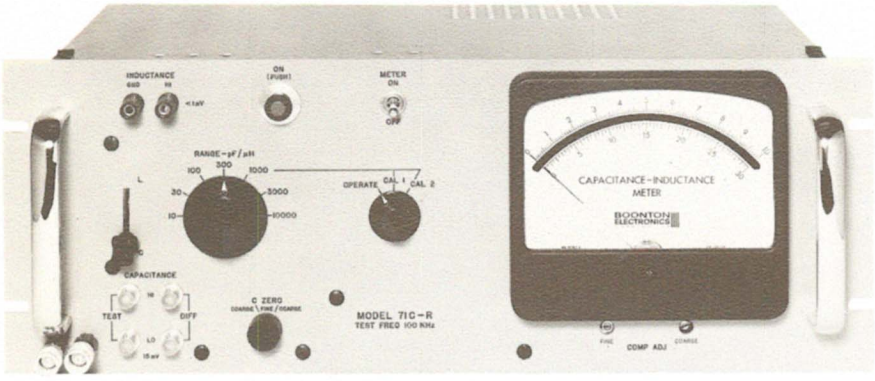
BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY

Model 71CR 100 kHz Capacitance/ Inductance Meter

Instant, Direct-Reading Measurement of Capacitance and Inductance at 100 kHz



☐ Capacitance Measurements (3-Terminal)

Range: . . . . . 0 to 0.01 μF in 7 ranges
Lowest Range: . . . 10 pF fs
Resolution: 0.25%
Accuracy: . . . . . $\pm$0.5% of reading + (0.5% + $\frac{3}{Q}$ %) fs + 0.1 pF

☐ Inductance Measurements (2-Terminal)

Range: . . . . . 0 to 10 mH in 7 ranges
Lowest Range: . . . 10 μH fs
Resolution: 0.25%
Accuracy: . . . . . $\pm$0.5% of reading + (0.5 + $\frac{6}{Q}$% + $\frac{\text{LmH}}{10}$ %) fs + 0.1 μH

☐ Crystal Controlled 100 kHz Test Signal

The Model 71CR, 100 kHz version of the Model 71A, provides capacitance and inductance measuring facilities comparable to those of the Model 71A, except for test frequency and ranges of measurement. Test levels, basic accuracies, dc bias provisions, and characteristics of the dc analog output remain unchanged.

The Model 71CR is designed for mounting in a standard 19″ rack, and measures 7″ h x 19″ w (panel size) x 9¼″ behind panel.

The Model 71CR provides precise, high resolution, three-terminal capacitance measurements and two-terminal inductance measurements with the speed and convenience of a vtvm. In addition the instrument offers an accurate dc analog of the test value.

The Model 71CR operates by metering the quadrature current through the test while ignoring the in-phase current, so that the instrument is not susceptible to errors resulting from specimen loss over a wide range of Q values.

Test signal-level for capacitance measurements is fixed at 15 millivolts, permitting tests on a wide variety of solid state devices. Test level for inductance measurements is less than 1 millivolt. The highly stable test signal is crystal controlled at 100 kHz.

Dc bias to $\pm$200 volts at 250 mA may be applied to the test through rear-panel terminals from an external supply.

The dc analog output is available at rear-panel terminals in two modes. In the "DVM" mode, amplitude range is from zero to either 100 or 300 millivolts for full scale, depending on the numerics of the selected range. Thus when used in conjunction with a dvm, correct numerics are automatically maintained when switching from range to range. In the "REC" mode the output varies from 0 to about 1.6 volts on all ranges for loads greater than 10 megohms.

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BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY

Model 71-1A
100 pF, 1 MHz
Standard Capacitor

A Precision Standard Capacitor for Both High and Low Q Calibration of the Model 71A Capacitance/Inductance Meter

The Model 71-1A is a compact, three-terminal, 1 MHz Standard Capacitor intended specifically for calibrating the Boonton Electronics Model 71A Capacitance/Inductance Meter*, and is designed to plug directly into the front-panel capacitance "TEST" terminals of the instrument.

It is adjusted to 100 pF (±0.25%) against references traceable to the National Bureau of Standards, and certification of traceability to the NBS is supplied at the time of purchase.

The Model 71-1A embodies a precision capacitor which provides for high Q calibration. In addition the Q can be reduced to 3 for low Q calibration by pressing a switch on the housing of the Standard.

While the Model 71A Capacitance/Inductance Meter may be calibrated with any three-terminal, 1 MHz standard capacitor, the Model 71-1A

The Model 71-1A Standard Capacitor plugs directly into the "TEST" terminals of the Model 71A Capacitance/Inductance Meter, and provides a particularly convenient means for checking both high Q and low Q performance of the instrument. Calibration of the Model 71-1A is traceable to the NBS.

is particularly convenient. In plugging directly into the test terminals without use of connecting coaxial cables, series lead inductance (which otherwise could cause errors requiring correction) is held to a minimum. The basic design of the Model 71-1A is such that the stray capacitance from each terminal to ground is small.

This, plus the elimination of connecting coaxial cables and their associated stray capacitance, simplifies compensation of capacitance from the "HI" post to ground with the "COMP ADJ" adjustment of the Model 71A.

While the Model 71-1A Standard Capacitor is intended for use primarily with the Model 71A Capacitance/Inductance Meter, it may be used by coaxial-cable connection with any three-terminal capacitance bridge operating over a frequency range from 1 KHz to 1 MHz, where an accuracy of ±0.25% will suffice.

* The Model 71-1A Standard Capacitor is built into the Model 71AR, Rack-Mounting version of the Model 71A.

BOONTON ELECTRONICS CORPORATION
PARSIPPANY, NEW JERSEY

Model CS- Three-Terminal Capacitance Standards

Precision Capacitance Standards for Checking Accuracy of Three-Terminal Capacitance Bridges

- Basic Accuracy, 0.1%
- Capacitance Values Available from 0.01 pF
- Usable from 1 KHz to 1 MHz
- Excellent Electrical Stability
- Rugged Mechanical Construction
- Calibrated against references certified by NBS

MODEL CS-
Three-Terminal Capacitance Standards

The Model CS- Capacitance Standards are convenient, reliable references for calibrating or checking the accuracy of three terminal capacitance bridges. Also, when connected to the standard arm of the bridge, they provide means for high-resolution comparison measurements.

These capacitance standards are designed for use over a frequency range from 1 KHz to 1 MHz, and are available in any value from 0.01 pF to 1000 pF. Standards having values of 1 pF or greater are adjusted to a basic accuracy of better than 0.1%; standards of smaller values are adjusted to basic accuracies better than 0.3%. In all cases certification is furnished which includes the actual measured value of the standard as well as the measured temperature coefficient. Accuracies of the references employed for calibration are certified directly by the National Bureau of Standards.

The Model CS- Capacitance Standards are characterized by low series inductance and low stray capacitance from each terminal to case ground to minimize loading effects. The capacitive elements of the standards are subjected to extensive heat cycling to assure the greatest possible thermal stability.

These standards are packaged in sturdy metal containers for mechanical protection and are equipped with BNC terminals for connection by coaxial cables to the bridge.

SPECIFICATIONS

Frequency Range: 1 KHz to 1 MHz

Capacitance Values Between:	Accuracy	Approximate Temp. Coefficient
100-1000 pf	± (0.1% +0.1 pf)	± 30 PPM/°C
10-100 pf	± (0.1% +0.01 pf)	± 30 PPM/°C
1-10 pf	± (0.1% +0.004 pf)	± 30 PPM/°C
0.01-1.0 pf	± (0.3% +0.0004 pf)	± 80 PPM/°C

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BOONTON ELECTRONICS CORPORATION
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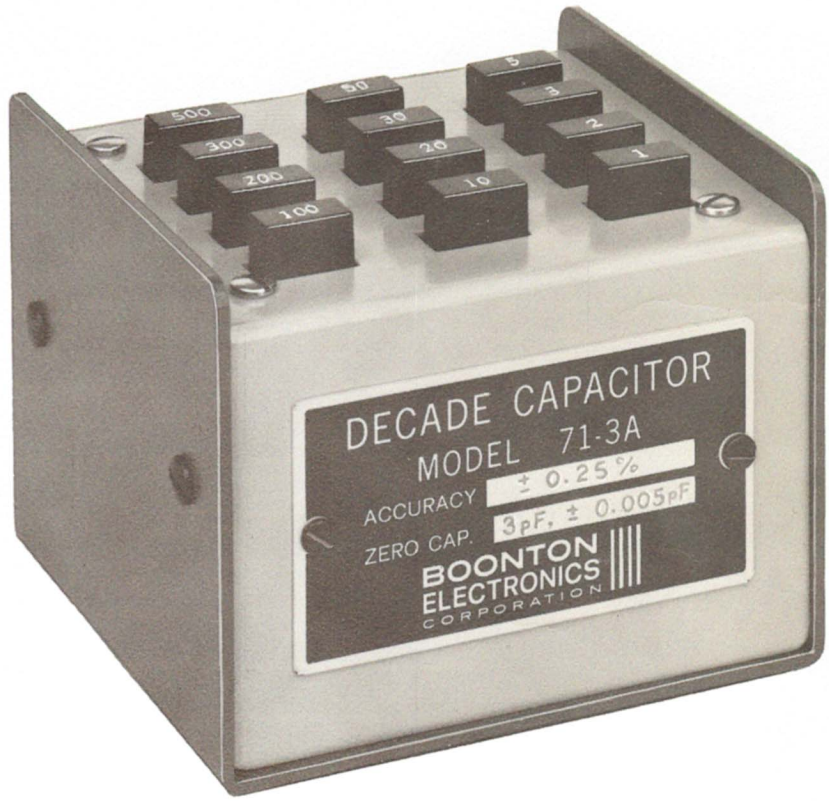
Model 71-3A Decade Capacitor

3-Terminal Decade Capacitor with Selectable 1 pF through 1221 pF Range in 1 pF Increments with Accuracy ±0.25%

The Model 71-3A Decade Capacitor is a three-terminal capacitor with selectable values of capacitance from 1 pF to 1221 pF in 1 pF increments. The unit can be used as a secondary standard for the calibration of capacitance bridges or capacitance meters. It may also be used as a reference capacitor for differential capacitance measurements. The residual capacitance of the 71-3A is 3 pF ±0.005 pF. This capacitance can be zeroed out on all Boonton Electronics Capacitance Bridges or Capacitance Meters. When used with instruments without provision for zeroing, the 3 pF must be added to the value selected with the pushbuttons.

Total Direct-Capacitance is that of the combined total of engaged pushbuttons (plus 3 pF, if this is not negated in the initial zeroing procedure).



SPECIFICATIONS

Range (△C): . . . . . 1 pF to 1221 pF
Incremental Capacitance: . . . . 1 pF
Zero Capacitance: . . . . . 3 pF ±0.005 pF
Accuracy (△C): . . . . . ±0.25%
Frequency: . . . . . 100 kHz to 1 MHz

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BOONTON ELECTRONICS CORPORATION
PARSIPPANY, NEW JERSEY

Model 71-10A Series Inductance/ Permeability Adapters

Converts 71A/700C 1 MHz C/L Meters for Measurement of Ultra-Low Values of Inductance and Measurement or Comparison of the Magnetic Permeability of Small Toroidal Cores.

The Model 71-10A Series Low Inductance Adapters make use of a unique principle of parallel resonance to linearly transform small changes of inductance to increments of capacitance which can be directly read on the 10 pF range of the Boonton Electronics Model 71A or 700C Capacitance/Inductance Meters. This change of inductance can result either from the addition of an inductor specimen into the measuring circuit at the binding posts or an increase in the inductance of the measuring circuit owing to the introduction of a magnetic toroidal sample into the single-turn demountable-loop test jig.

Two adapters are available with full scale ranges of 10 nH and 100 mH. Units with full scale ranges of 30 nH and 300 nH are available to special order.

INDUCTANCE MEASUREMENTS

Measurement of small values of self-inductance such as exist in switches, connectors, sockets, printed circuit boards, short cables, etc., can be made with the 71-10A. Three binding posts and a shorting link are provided. The shorting link is included for both the zeroing operation and the measurement of the unknown inductor, hence its value need not be known.

Many components having suitable connecting lugs or wires may be measured directly at the binding posts. The shorting link must be shifted to the TEST position and the test device connected between the terminals designated L_X.

With the unknown inductor connected, the meter will read the value directly, applying the appropriate multiplier, i.e. using a 71-10A/100 (100 nH, f.s.), a reading of 7 pF on the 10 pF range is equivalent to 70 nH. The circuitry of the 71-10A Low Inductance Adapter will permit remote measurements of inductance at a limited distance from the L_X terminals. The use of an extension cable, however, is not error free, but the error is predictable if the cable inductance is known. A foot, or more, of dual litz wire, the inductance of which is measurable on the Adapter, provides a suitable means for remote connection.

PERMEABILITY MEASUREMENTS AND COMPARISONS

Two demountable loops are available for the measurement and evaluation of magnetic toroidal cores. One loop is in the normal test circuit and, when encompassed by a core, the increase of inductance is a function of its relative initial permeability. A second loop, located in a network which balances the test circuit, may be equipped with a sample core of known characteristics to expand the sensitivity of the measurement by differential techniques.

Cores with permeabilities sufficiently high to normally produce off-scale readings, may be compared with a core of known permeability which can be installed in the STD loop. Because these measurements are relative, an instrument range, other than 10 pF, may be used to yield suitable on-scale readings.

A simple technique may be employed for the rapid comparison of low permeability cores by substituting a small hair-pin loop for the normal flat U-shaped demountable TEST loop. The test cores are placed over the loop and relative readings may be observed.

INSTALLATION

Only three interconnections are required between the 71-10A and the 71A (or 700C). The three cables attached to the 71-10A are marked LO TEST, LO DIFF, and HI. They connect to the appropriate terminals of the 71A (or 700C). Zero and calibrate-full-scale controls are provided, but once adjusted, the adapter is stable and not subject to drift.

ACCURACY REFERENCES

The accuracy of the 71-10A Low Inductance Adapter depends upon the value of the work coil and the calibrating capacitor in the Adapter. The work coil is toroidally wound on a powdered iron core of relatively low permeability and is therefore electrically stable. The calibrating capacitor is factory set and should not require adjustment. If a check is necessary, it can be measured on a Boonton Electronics 1 MHz Capacitance Bridge, Model 75A, 75B, 75D, or 77B.

Q MEASUREMENTS

The Model 71-10A Low Inductance Adapters may also be used with Boonton Electronics Model 75D and 77B three-terminal 1 MHz Capacitance Bridges. The capacitance and conductance readings on the bridge at balance are related to the inductance and Q of the test specimen. The relationship is not direct but values may be calculated from formula provided.

SPECIFICATIONS

71-10A/10

Full Scale Range: ..... 10 nanohenries
Accuracy: ..... ± 5% fs
Resolution: ..... 0.25% fs
Linearity: ..... Better than 1%

71-10A/100

Full Scale Range: ..... 100 nanohenries
Accuracy: ..... ± 3% fs
Resolution: ..... 0.25% fs
Linearity: ..... Better than 1%

Each 71-10A Adapter is supplied with 12 inch cables for connection to the 71A or 700 Series C/L meter. The separation may be increased to approximately 3 feet with extension cables.

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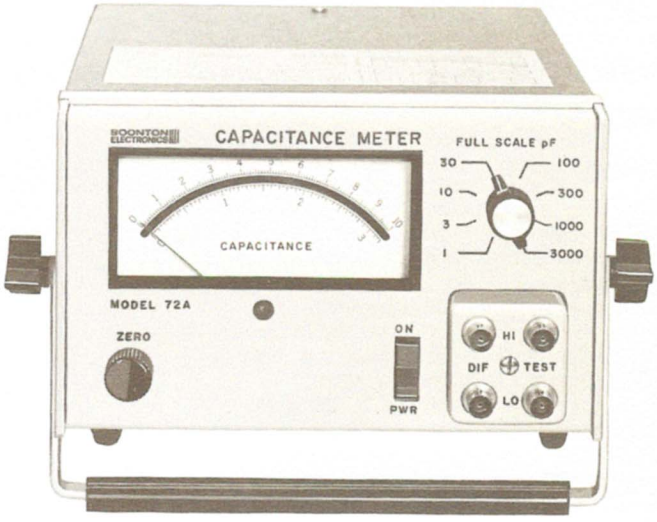
BOONTON ELECTRONICS CORPORATION
PARSIPPANY, NEW JERSEY U.S.A.

Model 72 Series Capacitance Meters

Programmable 3-Terminal 1 MHz Capacitance Meters with Digital or Analog Readout.

Digital Model 72AD



Analog Model 72A

FEATURES

- ☐ Four ranges: 1.999 pF fs to 1999. pF fs.
- ☐ Test level, 15 mV rms; test frequency, 1 MHz.
- ☐ BCD and high speed analog outputs.
- ☐ Accuracy: ±0.25% rdg ±0.025% fs ±1 digit.
- ☐ Programmable.
- ☐ Optional autoranging.
- ☐ Provision for dc bias to ±600 V.
- ☐ Three-terminal input permits remote testing.
- ☐ Tolerates Q values as low as 1.

- ☐ Eight ranges: 1 pF fs to 3000 pF fs.
- ☐ Test level, 15 mV; test frequency, 1 MHz.
- ☐ High speed DC analog output.
- ☐ Accuracy: ±0.5% rdg ±0.5% fs.
- ☐ 0.5% fs resolution.
- ☐ Programmable.
- ☐ Provision for dc bias to ±600 V.
- ☐ Three-terminal input permits remote testing.
- ☐ Tolerates Q values as low as 1.

TYPICAL APPLICATIONS

- ■ Semiconductor junction capacitance measurement on all devices including varactors.
- ■ C/V characteristic plots to study, for example, doping profiles. (With suitable plotter.)
- ■ Computer interfaced capacitance measurements.
- ■ Linearity classification or batching of varactors for capacitance. (Within a multi-point C/V test system.)
- ■ Remote capacitance measurements such as required with most automatic handling systems or environmental test set-ups.
- ■ Sequential monitoring of disparate values of capacitance. (Model 72AD with autoranging option —01.)

INTRODUCTION

The Model 72 Series of solid-state capacitance meters provide rapid, accurate, three-terminal and differential measurements of capacitance over a wide range. They are particularly well suited to measurements of semiconductor devices because of the low test level employed (15 mV rms), and the provision for application of dc bias to the test.

The phase-sensitive detection system used allows the capacitance of even low-Q devices (as low as Q=1) to be measured with little reduction in accuracy. Range switching is accomplished by a combination of logic-controlled reed relays and diodes. Range selection is by front panel switch or remote logic-level inputs.

Both models provide a highly linear, high speed, dc analog voltage output corresponding to the meter or display indication. In addition, the 72AD has BCD outputs, TTL compatible. Autoranging of this model is available as an option.

Adapters are supplied for coaxial-cable connection to a remote test fixture, and for direct attachment of wire lead components. As a three-terminal instrument, the Model 72 is relatively insensitive to the cable shunt capacitance from either side of the test to ground.

Compactly half-rack packaged, the Model 72 Series may also be rack-mounted, singly or in pairs, using the rack-mounting kits available.

SPECIFICATIONS

Digital Model 72AD

Capacitance Ranges: 1.999, 19.99, 199.9, 1999 pF fs . (1, 10, 100, 1000 pF with 100% overrange.)

Accuracy: Test Q > 5: ±(0.25% rdg + 0.025% fs + 1 digit*)
Test Q=1 to 5: ±(0.5% rdg + 0.025% fs + 1 digit*)
*add 0.005 pF cn lowest range.

Display: Nixie-type, 3½ digits; display period 250 ms; encode period 10 ms.

Data Outputs:

Digits: 8, 4, 2, 1 code, digit parallel .

Range: Programming lines are used to indicate range, logic 0 true.

Encode Complete: Transfer logic 0 to logic 1.

Polarity: Logic 1 indicates negative.

Overrange: Logic 0 indicates > 100% fs.

Underrange: Logic 0 indicates <9% fs.

Commands:

Range: Logic 0 selects range (4 lines).

Manual Disable: Logic 0 disables front panel switch.

Autorange Enable: Logic 0 selects autorange if —01 option is installed.

Encode Hold: Logic 0 inhibits start of new encode cycle for delayed data transfer.

Encode Trigger: Transition logic 1 to logic 0 initiates encode cycle. Encoding is complete in 10 ms and digital output data is then available. Trigger pulse fall time < 100 ns; width 1 μs to 1 ms.

Logic Levels: Logic 1 > + 3 V; logic 0 < + 0.5 V; TTL compatible.

DC Output: 2 V ±0.5% for fs all ranges; linearity ±(0.1% rdg + 0.005% fs) source resistance 1000 Ω. Response time < 0.5 ms for full accuracy. Noise < 2 mV rms.

Power: 115 or 230 V ±10%; 50 to 400 Hz; 16 watts.

Weight: Net 8 lbs. (3.7 kg)

Option: Autoranging. Automatically upranges at 1999, downranges at 180. Ranging time: 100 ms per range. To order use suffix —01.

Analog Model 72A

Capacitance Ranges: 1, 3, 10, 30, 100, 300, 1000, 3000 pF fs.

Accuracy: Test Q > 5: ±(0.5% rdg + 0.5% fs*)
Test Q=1 to 5: ±(1.0% rdg + 0.5% fs*)
*add 0.005 pF on lowest range.

Resolution: 0.5% fs for each range.

Meter: 4½ inch taut-band type; two linear scales, 0 to 10 (0.1 per division) and 0 to 30 (0.5 per division).

Commands:

Range: Logic 0 selects each range (8 lines).
Logic 1 > + 3 V, logic 0 < + 0.5 V TTL compatible.

Manual Disable: Logic 0 disables front panel switch.

DC Output: 1 V ±0.5% for fs (1 series ranges); 3 V ±0.5% for fs (3 series ranges). Linearity: ±(0.1% rdg + 0.01% fs) Response time 0.5 ms for full accuracy.

Power: 115 or 230 V ±10%; 50 to 400 Hz; 9 watts.

Weight: Net 7.2 lbs. (3.3 kg).

SPECIFICATIONS

Models 72A and 72AD

Test Signal: 1 MHz, crystal-controlled; 15 mV rms.

Differential Measurements: Maximum capacitance on DIFF terminals for specified accuracy is the fs value of range in use. (Autoranging may not be used for differential measurements)

Capacitance Loading Tolerances: Input configuration is three-terminal. Measurements are unaffected by capacitive loading within these limits.

a) LO post to ground: 500 pF maximum on all ranges.

b) HI post to ground:

Range	Max. C
1 pF, 3 pF	100 pF
10 pF, 30 pF	250 pF
100 pF, 300 pF	500 pF
1000 pF, 3000 pF	500 pF

DC Bias: External dc bias may be applied to the test via rear terminals or programming connector.
HI to GND: ±200 V max.
LO to GND: ±400 V max.
LO to HI: ±600 V max. (floating supply only)

Temperature Influence:

Temperature Range	Max. Influence
Reference 20°C to 25°C	0
Normal 18°C to 30°C	0.2% of rdg
Extreme 10°C to 40°C	0.5% of rdg

Dimensions: 5.2″ high, 8.3″ wide, 12″ deep (132 x 211 x 305 mm) excluding handle, feet and knobs.

Accessories Furnished: Two connection adapters:
a) BNC for remote connections to TEST and DIFF terminals.
b) Grip-posts for local connection to TEST (axial-lead components).

Accessories Available: Single rack-mounting kit (mounts left or right) 92-1A. Dual rack-mounting kit 92-1B.

ROUTE 287 AT SMITH RD., PARSIPPANY, N. J. 07054 U.S.A. • TEL.: 201-887-5110 TWX: 710-986-8241

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BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY

Model 74D 100 KHz Capacitance Bridge

100 kHz Wide Range Capacitance Bridge Providing Two or Three-Terminal Measurements with a Basic Accuracy of 0.1 Percent

- Capacitance range: 0.0002 pF to 0.11 μF
- Conductance range: 0.001 μmho to 1mmho
- Resistance range: 1kΩ to 1GΩ
- Remote measurements with three-terminal (direct) operation; conventional two-terminal (grounded) operation also provided
- No false or sliding nulls; simple, convenient balancing; all zeroing controls vernier driven
- Test signal internally supplied; continuously adjustable from 4 volts down to 1 millivolt

- Excellent stability; negligible warm-up drift
- DC bias internally supplied; connection for external bias
- Limit mode for go/no-go testing
- Operable as comparison bridge

General

The Model 74D is a true "state-of-the-art" capacitance bridge providing capicitance measurements over broad ranges, under a wide variety of test conditions, and with a degree of accuracy not previously available. The instrument is completely self-contained, including bridge circuitry, 100 kHz test oscillator, detector, dc bias source, and related power supplies, all in a single compact bench cabinet. (The Model 74D is built on a 19-inch chassis and may be mounted in a standard rack when removed from its cabinet.)

Capacitance Measurement

Five decade capacitance ranges plus a selector switch that connects from one to 10 internal precision mica capacitors to the standard arm provide continuous measurement from 0.0002 pF to 0.11μF. Basic accuracy of capacitance measurement is 0.1 percent (see Table of Specifications).

In spite of the unusually broad capacitance range of the Model 74D, readability is excellent even down to the smallest measurable values. For example, on the lowest capacitance range (0 to 1 pF) the

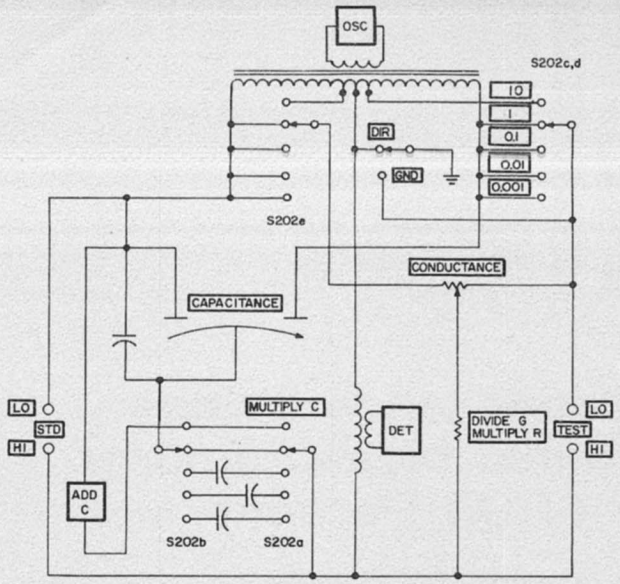

Figure 1. Simplified schematic of Model 74D

single picofarad is spread over 5000 divisions on a scale effectively more than 200 inches long. The combination of the "counter" dial and 40:1 vernier provides convenience and speed in scanning together with great accuracy of fine adjustment.

Conductance and Resistance Measurements

The conductance dial of the Model 74D is also calibrated in parallel resistance. Five decade ranges provide measurements continuously from 0.001 μmho to 1mmho and from 1kΩ to 1GΩ. Since the conductance and capacitance balancing networks are essentially independent of each other, the range setting for one parameter has no bearing on the setting of the other. In addition, this lack of interaction between the capacitance and conductance arms assures convenient, straightforward balancing without the annoyance of false nulls or sliding balance.

Bridge Circuitry

A simplified schematic of the Model 74D is shown in Figure 1. The bridge is a modified Young circuit in which both the main capacitance balance control and the capacitance zero control are variable differential air capcitors. Use of differential air capacitors contributes to the overall bridge stability since the capacitive elements in each arm are subjected to **identical** thermal conditions. This would not necessarily be the case were two separate components used.

Great care is taken in the design of the main differential capacitor, in its metallurgy, in the fabrication and assembly of its parts, and in its final adjustment to assure the highest degree of accuracy and stability within the limits of the state of the art. The unique design and construction of the mechanical linkage between this capacitor and the dial hold back-lash to a minimum, permitting full advantage to be taken of the resolution capability of the bridge.

The range selector **("Multiply C")** comprises a network of highly stable air capacitors which are adjusted to an accuracy of better than 0.1 percent.

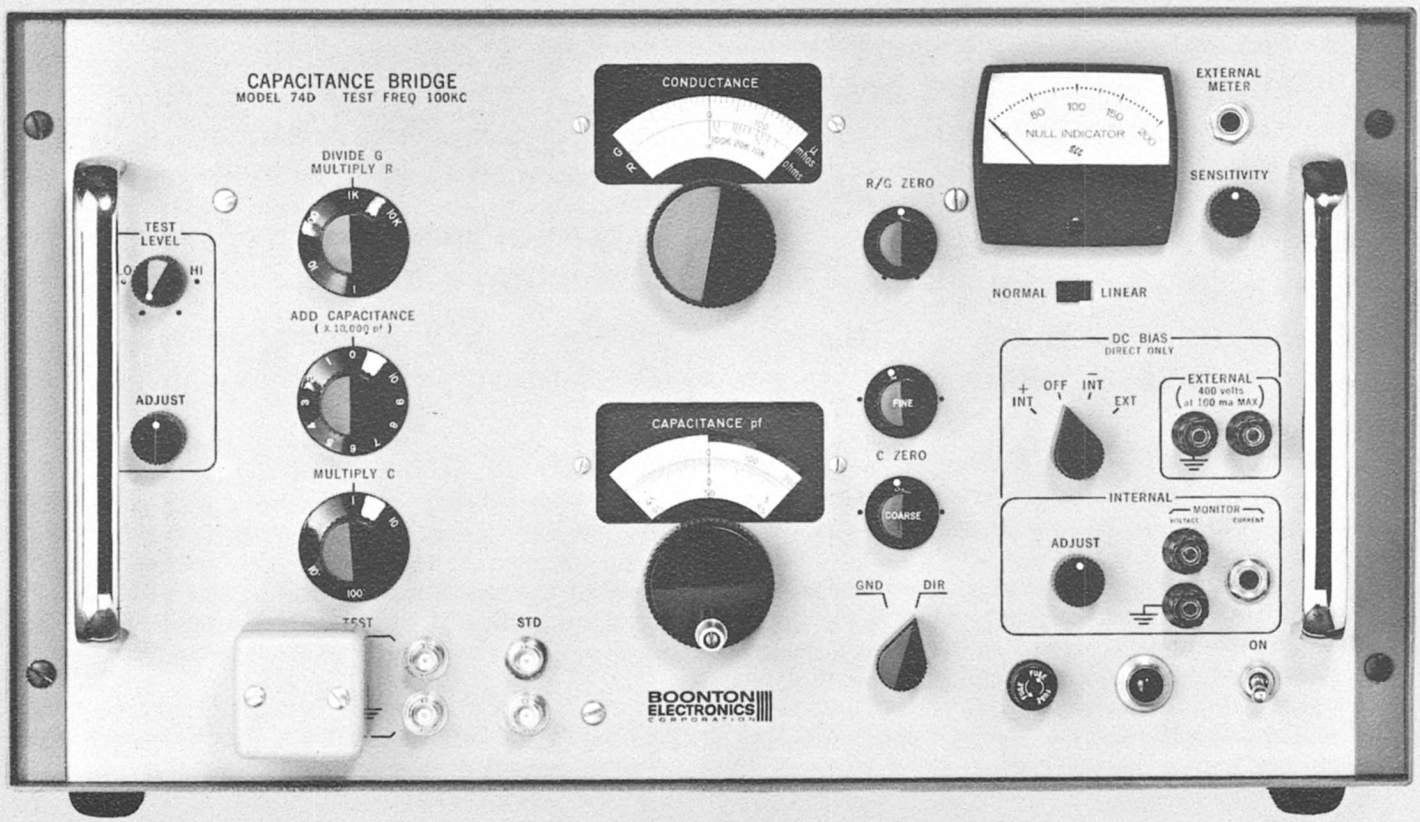

Figure 2. Front panel view of Model 74D

Test Signal

The level of the internally supplied test signal is continuously adjustable from 4 volts down to approximately 1 millivolt, and may be conveniently measured with a sensitive RF Voltmeter such as one of the Boonton Electronics Corp. 91 Series. With the three terminal arrangement of the Model 74D, the test signal level may be continuously monitored (between the "LO" terminal and ground) during successive measurements without affecting the accuracy of test results.

Accuracy of the test frequency is 1 percent. (It should be noted that the precision of the test frequency is rarely critical and in the great majority of cases frequency variations within this specification have no measurable effect on the accuracy of measurement. In the unusual circumstance where greater precision of frequency is required, a counter may be used to monitor the test signal and to adjust it more accurately.

The wide range of control over the test signal level is valuable for measurements on such non-linear devices as diodes and transistors, where low test levels are usually required in order to obtain a clearly defined null on bridge balance, as well as in cases where measurements are made on components whose capacitance varies with the test signal voltage.

Total distortion of the test signal generator output is 35 db or more below the fundamental. This is an important consideration when measurements are to be made on non-linear devices such as diodes, since asymmetry of the wave form would result in readings that would differ depending on the polarity in which the component is connected to the test terminals.

DC Bias

An internal dc supply provides a voltage which is continuously variable from +110 volts to −7 volts for biasing the test specimen when making direct (three-terminal) measurements. This bias voltage may be monitored by connecting an external meter to front panel jacks. Provision is also included for application of an externally supplied bias up to ±400 volts at 100 milliamperes. The dc bias feature is of special importance for measurements of a number of voltage sensitive devices such as voltage variable capacitors.

Remote Measurements

In addition to the regular test binding posts, BNC receptacles at the front panel allow connection of coaxial cables for remote measurements. In the Three-Terminal (Direct) Mode the bridge is essentially insensitive to impedances from either side of the test to ground. Thus the capacitance of the connecting coaxial cables can be ignored, and errors resulting from changes in cable position or cable temperature are eliminated. As a result the capacitance (or changes in capacitance) of the test specimen alone may be accurately measured even when the specimen and connection system are exposed to wide variations in temperature, to vibration, or to other extreme environmental conditions.

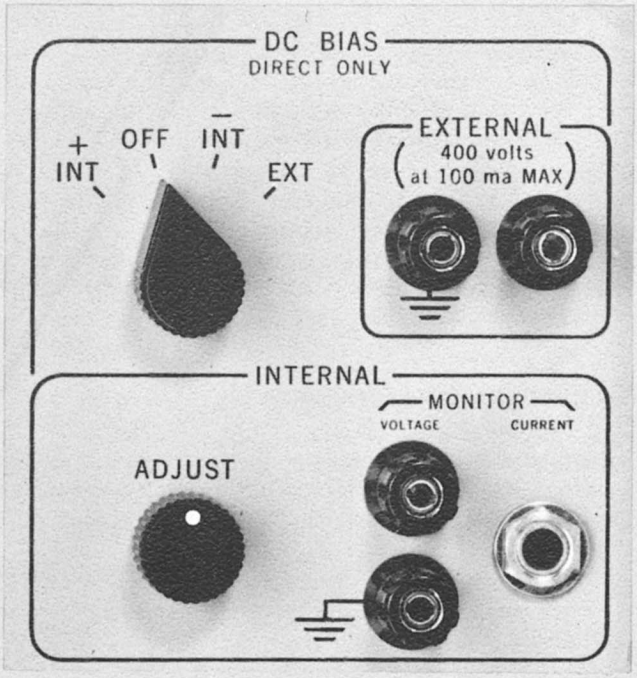

Figure 3. Detail of front panel showing dc bias controls. Internal dc bias supply is standard on all Model 74D's. Both bias voltage and current may be metered at panel connectors.

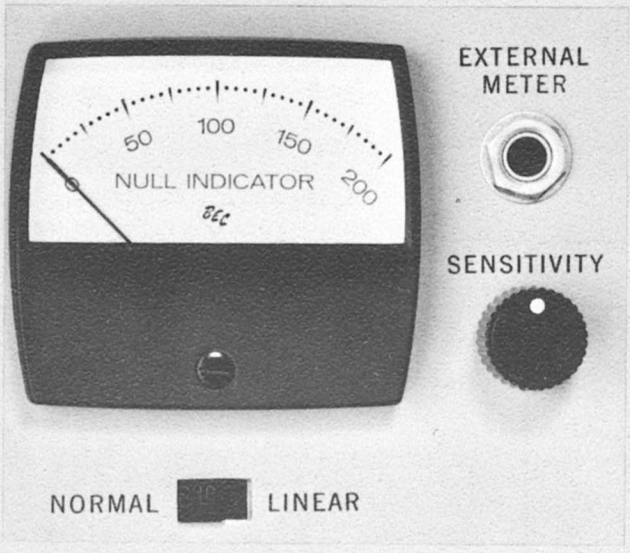

Figure 4. Detail of front panel showing null indicator. In the "Linear" mode, metering current and meter readings are directly proportional to bridge unbalance so that the meter can be "calibrated" to read directly in percent of deviation from a nominal capacitance value for go/no-go testing. The "External Meter" jack permits remote monitoring, or use of a relay type meter for actuation of associated equipment.

Limit (Go/No-Go) Operation

An unusual feature of the Model 74D is the ability to switch from "Normal" to "Linear" operation, per-

mitting use of the instrument as a capacitance limit bridge. A front panel switch disables the AGC circuit in the detector so that the null metering current becomes directly proportional to the capacitance or conductance unbalance. Thus the null indicator reading represents a given percent of deviation from the nominal value, and go/no-go tests may readily be made. The metering current is also brought out to a panel jack permitting use of a relay type meter for actuation of external equipment in conformance with limit test decisions.

Comparison Measurements

The standard arm of the bridge is accessible by means of BNC connectors at the front panel so that external standards or balancing capacitors may be attached. Thus the Model 74D may be used as a comparison bridge or for differential measurements such as the temperature coefficient of capacitors. With the differential sensitivity of the X 0.001 multiplier, the resolution of temperature coefficient measurements is in the order of 1 part per million for values above 200 pF.

Stability

After one hour warm-up, drift of true capacitance in the Model 74D is typically less than 0.001 pF for a 24-hour period. This excellent stability is particularly important for studies of extended duration, such as those involving determination of temperature coefficient. Freedom from drift is important, too, for limit operations since it permits setting up the bridge to a given capacitance and making go/no-go tests over a length of time with the assurance that the nominal value setting has not shifted.

SPECIFICATIONS

Capacitance Ranges:

Multiplier	Cap. Range	Smallest Division	Direct	Grounded
10	0 pF to 0.11 μF	2 pF	$\pm (0.25\% + \frac{1000}{Rp}\% + 2\text{ pF})$	$\pm (0.25\% + \frac{1000}{Rp}\% + 2\text{ pF})$
10	0 pF to 10,000 pF	2 pF	$\pm (0.1\% + \frac{1000}{Rp}\% + 2\text{ pF})$	$\pm (0.1\% + \frac{1000}{Rp}\% + 2\text{ pF})$
1	0 pF to 1000 pF	0.2 pF	$\pm (0.1\% + \frac{1000}{Rp}\% + 0.2\text{ pF})$	$\pm (0.1\% + \frac{1000}{Rp}\% + 0.5\text{ pF})$
0.1	0 pF to 100 pF	0.02 pF	$\pm (0.1\% + \frac{1000}{Rp}\% + 0.05\text{ pF})$	$\pm (0.1\% + \frac{1000}{Rp}\% + 0.5\text{ pF})$
0.01	0 pF to 10 pF	0.002 pF	$\pm (0.1\% + \frac{1000}{Rp}\% + 0.01\text{ pF})$	$\pm (0.1\% + \frac{1000}{Rp}\% + 0.5\text{ pF})$
0.001	0.05 pF to 1 pF	0.0002 pF	$\pm (0.1\% + \frac{1000}{Rp}\% + 0.02\text{ pF})$	$\pm (0.1\% + \frac{1000}{Rp}\% + 0.5\text{ pF})$
0.001	0 to 0.05 pF	0.0002 pF	$\pm (2.00\% + \frac{1000}{Rp}\% + 0.0002\text{ pF})$	———

* Rp = Equivalent parallel resistance of test in OHMS

Conductance Ranges:

Divider	Cond. Range	Accuracy
1	0 to 1 mmho	$\pm (10\% + \frac{Q}{500}\% + 10\ \mu\text{mhos})$
10	0 to 100 μmhos	$\pm (5\% + \frac{Q}{500}\% + 1\ \mu\text{mho})$
100	0 to 10 μmhos	$\pm (5\% + \frac{Q}{500}\% + 0.1\ \mu\text{mho})$
1K	0 to 1 μmho	$\pm (5\% + \frac{Q}{500}\% + 0.01\ \mu\text{mho})$
10K	0 to 0.1 μmho	$\pm (5\% + \frac{Q}{500}\% + 0.001\ \mu\text{mho})$

Resistance Ranges:

Multiplier	Resistance Ranges	Accuracy
1	1K to 100K ohms	$\pm (10\% + \frac{Q}{500}\% + \frac{R}{10^3}\%)$
10	10K to 1 megohm	$\pm (5\% + \frac{Q}{500}\% + \frac{R}{10^4}\%)$
100	100K to 10 megohms	$\pm (5\% + \frac{Q}{500}\% + \frac{R}{10^5}\%)$
1K	1 megohm to 100 megohms	$\pm (5\% + \frac{Q}{500}\% + \frac{R}{10^6}\%)$
10K	10 megohms to 1 gigaohm	$\pm (5\% + \frac{Q}{500}\% + \frac{R}{10^7}\%)$

TEST FREQUENCY: 100 KHz with self-contained oscillator and detector; accuracy of test frequency, ±1%

TEST SIGNAL LEVEL: Continuously adjustable from 1 mV to 4 V

DC BIAS: Internally supplied; continuously adjustable from +110 V to −7 V; external bias up to ± 400 V at 100 mA

"LINEAR" OPERATION: Selected by front panel slide switch; null indicator current and meter reading directly proportional to bridge unbalance; full scale capacitance deviation limits: max., 4000 pF; min., 0.002 pF

POWER REQUIREMENTS: 105-125 V, 50-60 Hz; 30 watts (210-240 V, 50-60 Hz version also available at no additional cost)

PHYSICAL SPECIFICATIONS: 19½" w x 10¾" h x 11¼" d in cabinet; with cabinet removed, mounts in standard 19" rack; weight 35 lbs

BOONTON ELECTRONICS CORPORATION

specifications are subject to change without notice.

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BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY

Model 75C Variable Frequency Three-Terminal Capacitance Bridge

Precise Measurements of Capacitance and Loss From 5 KHz to 500 KHz

- Capacitance from 0 to 1000 pF; Resolution, 0.0002 pF; Basic Accuracy, 0.25%
- Conductance from 0 to 1000 μmhos; Resolution, 0.001 μmho
- Resistance from 1000 Ω to 1000 MΩ
- Test frequency continuously variable from 5 KHz to 500 KHz
- Test level continuously variable from 3V to below 1 mV
- Internally supplied dc bias
- Remote measurements via coaxial cables

- High resolution differential measurements
- No false nulls or sliding balance
- Completely self-contained, including bridge circuitry, variable frequency oscillator, and tunable detector

GENERAL DESCRIPTION

The Model 75C is a precise, high resolution bridge which makes direct reading measurements of capacitance, conductance, and parallel resistance over a frequency range that is continuously adjustable from 5 KHz to 500 KHz.

In providing the facility for measuring components, networks, and materials under widely adjustable conditions of test level, test frequency, and dc bias, the Model 75C comprises a research tool of substantial value.

Because this is a three-terminal instrument, remote measurements may be made via coaxial cables, and the specimen may be mounted in a test fixture or in an environmental chamber without incurring errors resulting from stray capacitance from either side of the test to ground.

In addition to the TEST connections, the STANDARD arm of the bridge is also accessible through front panel BNC connectors, permitting use of external capacitors for differential or comparison measurements. This, combined with the instrument's excellent stability, makes the Model 75C particularly useful for high resolution temperature coefficient measurements. The Model 75C is completely self-contained including bridge circuitry, test oscillator, detector, and bias supply; no external accessory equipment is required for operation.

CAPACITANCE MEASUREMENTS

Capacitance is read directly in pF from the main capacitance dial. The measuring range of 0.0002 pF to 1000 pF is covered in four decade multiplier ranges.

The main capacitance dial consists of a "counter" plus a 40:1 vernier which provides speed and convenience in scanning, together with great accuracy of fine adjustment. This arrangement results in a capacitance scale which is effectively over 200 inches long for each multiplier range; on the lowest range a single picofarad is spread across 5000 divisions.

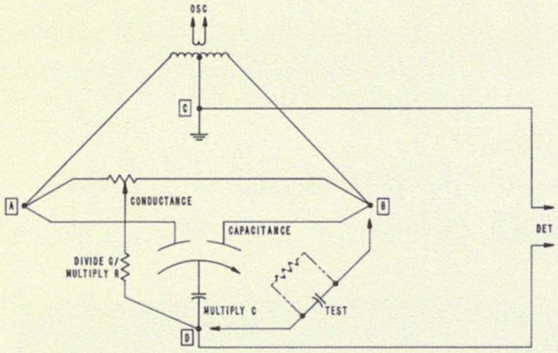


Figure 1. Simplified diagram of Model 75C

CONDUCTANCE/RESISTANCE MEASUREMENTS

Conductance and parallel resistance are also read directly from a front panel dial. The range of 0.001 μmho to 1000 μmhos (1000 ohms to 1000 megohms) is covered in 5 decade steps. The ability of the Model 75C to measure down to such small values of conductance makes the instrument suitable for testing very high Q components. Since the conductance and capacitance balancing networks are independent of each other, the range setting for one has no influence on that for the other. In addition, this lack of interaction between the two arms assures convenient balancing without the annoyance and ambiguity of false nulls or sliding balance.

THEORY OF OPERATION

A simplified diagram of the Model 75C is shown in figure 1.

Bridge Circuit

The bridge is a modified Young circuit. The output of the variable frequency oscillator is applied to the bridge input transformer through low impedance link coupling. The secondary of the input transformer is an integral part of the bridge network, providing effectively two generators with a common ground which produce signals that are equal in amplitude and opposite in phase. The low impedance of the secondary minimizes the effects of shunt capacitance. And with the extremely tight coupling between the two secondary windings, loading effects on one side affect the other side **equally.** Thus, capacitance from the LO post to ground has negligible influence on the balance of the bridge.

Any capacitance from the HI post to ground is shunted across the detector where its only practical effect is a reduction of detector sensitivity.

As a result of this arrangement only the capacitance between the HI and LO posts has significant effect on the balance condition of the bridge, permitting measurements which are essentially unaffected by capacitance from either side of the test to ground.

The main balance control is a variable differential air capacitor built to the most exacting standards to assure maximum stability. Use of a differential capacitor also contributes to the overall bridge stability since the capacitive elements in each arm are subjected to identical thermal conditions.

The unique design and construction of the mechanical linkage connecting this capacitor to its associated dial hold backlash to negligible proportions, permitting full advantage to be taken of the high resolution capabilities of this bridge.

Capacitance range multiplication is accomplished by selectively inserting one of the multiplier capacitors in series between the main balance capacitor and the HI post. These range multipliers are stable variable air capacitors which are adjusted to accuracies of 0.1 percent or better.

The conductance control is an infinite resolution potentiometer connected between the standard and test arms of the bridge with its center arm connected to the HI post. The conductance range is multiplied by switching one of the G MULTIPLIER resistors in series between the center arm of the potentiometer and the HI post. These resistors have excellent thermal stability and low capacitance so that their insertion in the bridge network has no practical effect on bridge stability or capacitance accuracy.

Test Oscillator

The resistance tuned Wien-bridge oscillator is continuously adjustable in frequency from 5 KHz to 500 KHz in a single range by means of a directly calibrated front-panel control. Accuracy is $\pm$5% of setting. The frequency can be set more precisely by connecting a counter between the LO post and ground, and may be monitored during measurements without affecting the performance of the bridge in any way.

Test level is continuously adjustable from approximately 3 volts down to less than 1 millivolt, and may be monitored without interfering with measurements by connecting an ac voltmeter between the LO post and ground.

The wide range of control over the test signal level is valuable for measurements on such devices as diodes and transistors, where low test levels are usually required to obtain a clearly defined null, as well as in cases where measurements are made on components whose capacitance varies with the test signal voltage.

Detector

The bridge output is applied directly from the HI post to a broad-band preamplifier. Frequency selection is accomplished by a Wein-bridge type tuned amplifier which provides 30 dB of attenuation of the second harmonic of the selected frequency over the total range of the oscillator. There follow two stages of high-gain, broad-band amplification before rectification and metering.

An agc voltage applied to the preamplifier and first broadband amplifier reduces the system gain for high output levels to eliminate off-scale null indications which might otherwise hamper locating the null.

DC BIAS

Provision is included in the Model 75C for applying dc bias to the test specimen from an internal supply. The bias voltage is continuously variable from −5 volts to +110 volts. Connectors are provided at the front panel to permit monitoring the bias level with an external voltmeter.

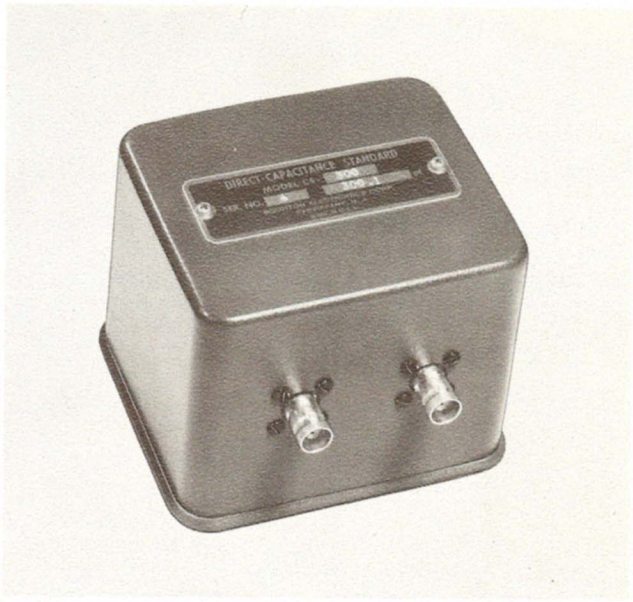
REMOTE MEASUREMENTS

The three-terminal arrangement of the Model 75C permits locating the test specimen remotely from the TEST terminals, since the bridge is essentially insensitive to capacitance from either side of the test to ground. As a result the capacitance of the connecting cables can be ignored, and errors resulting from changes in cable position or cable temperature are eliminated. The characteristics of the specimen alone may be accurately measured even when the connection system is exposed to wide temperature variations, to vibration, or to other extreme environmental conditions.

DIFFERENTIAL MEASUREMENTS

The standard arm of the bridge is accessible through BNC connectors at the front panel so that external standards or balancing capacitors may be attached. Thus, the Model 75C may be used for comparison or differential measurements. This is particularly valuable for temperature coefficient studies where the differential sensitivity of the lowest multiplier range can be used for capacitors having large values. Resolution for temperature coefficient measurements is of the order of ±(0.0001% of nominal capacitance +0.0002 pF) or 1 ppm °C for values above 200 pF.

MODEL CS CAPACITANCE STANDARDS



Precision standards for checking accuracy or calibrating three-terminal capacitance bridges, or for use as highly stable references for temperature coefficient measurements or other comparison studies; available in any value from 0.01 pF to 1000 pF; frequency range, 1 MHz to 1 KHz; basic accuracy, 0.1%; calibrated against references directly traceable to the National Bureau of Standards.

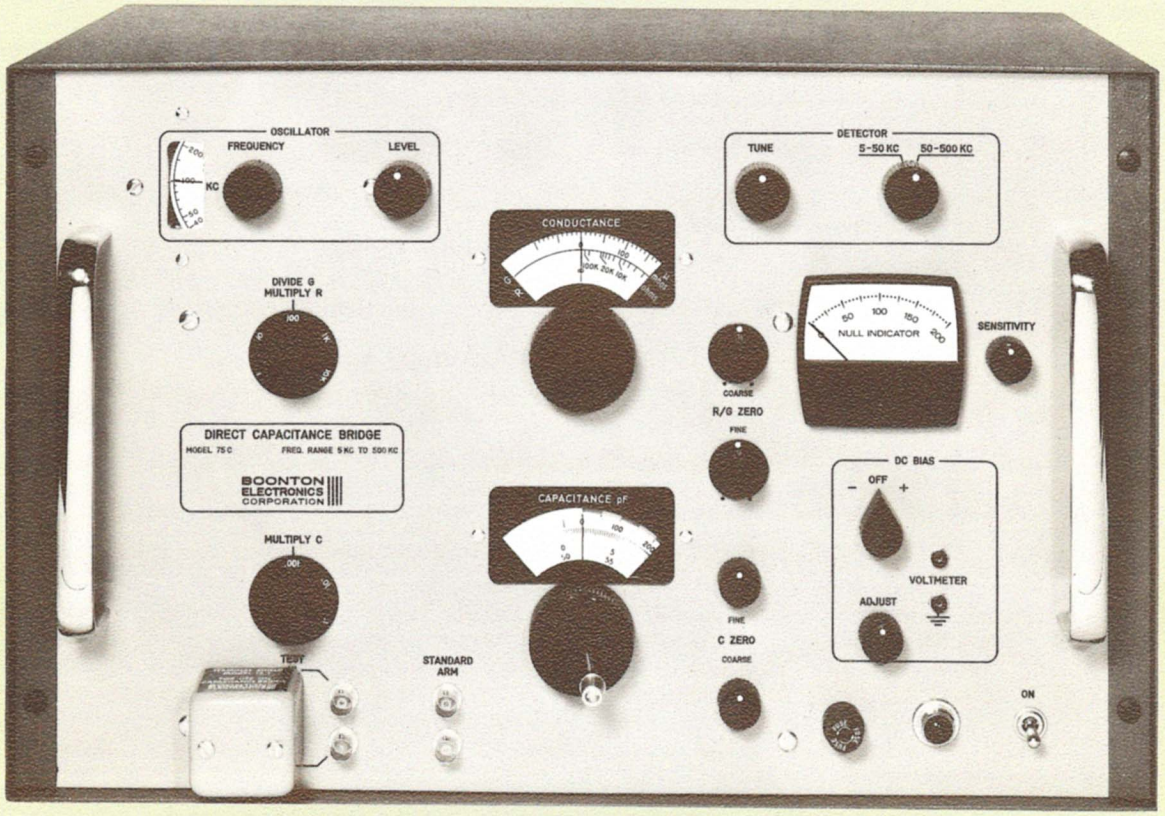


Figure 2. Front panel view of Model 75C

SPECIFICATIONS

Capacitance Range:

0 to 1000 pF in 4 decade ranges

Capacitance Accuracy and Resolution

C Multiplier	C Range, pF	C Resolution, pF	Accuracy *
1.0	0 to 1000	0.2	$\pm (0.25\% + \frac{1000}{Rp}\ pF + 0.2\ pF)$
0.1	0 to 100	0.02	$\pm (0.25\% + \frac{1000}{Rp}\ pF + 0.02\ pF)$
0.01	0 to 10	0.002	$\pm (0.25\% + \frac{1000}{Rp}\ pF + 0.005\ pF)$
0.001	0.05 to 1	0.0002	$\pm (0.25\% + \frac{1000}{Rp}\ pF + 0.001\ pF)$
0.001	below 0.05	0.0002	$\pm (2\% + \frac{1000}{Rp}\ pF + 0.0002\ pF)$

*where Rp is the equivalent parallel resistance of the test in ohms.

Conductance Range:

0 to 1000 μmhos in 5 decade ranges

Conductance Accuracy and Resolution

G Divider	G Range, µmhos	G Resolution, µmhos	G Accuracy†
1	0 to 1000	10	$\pm (10\% + \frac{Q}{500}\% + 10\ \mu mhos)$
10	0 to 100	1	$\pm (10\% + \frac{Q}{500}\% + 1\ \mu mho)$
100	0 to 10	0.1	$\pm (10\% + \frac{Q}{500}\% + 0.1\ \mu mho)$
1000	0 to 1	0.01	$\pm (10\% + \frac{Q}{500}\% + 0.01\ \mu mho)$
10,000	below 0.1	0.001	$\pm (10\% + \frac{Q}{500}\% + 0.001\ \mu mho)$

†at HI and LO TEST binding posts only.

Resistance Range:

1000 ohms to 1000 megohms in 5 decade ranges

Resistance Accuracy

R Multiplier	R Range, ohms	Accuracy†
1	1KΩ to 100KΩ	$\pm (10\% + \frac{Q}{500}\% + \frac{R}{10^3}\%)$
10	10KΩ to 1MΩ	$\pm (10\% + \frac{Q}{500}\% + \frac{R}{10^4}\%)$
100	100KΩ to 10MΩ	$\pm (10\% + \frac{Q}{500}\% + \frac{R}{10^5}\%)$
1000	1MΩ to 100MΩ	$\pm (10\% + \frac{Q}{500}\% + \frac{R}{10^6}\%)$
10,000	10MΩ to 1000MΩ	$\pm (10\% + \frac{Q}{500}\% + \frac{R}{10^7}\%)$

† at HI and LO TEST binding posts only.

Test Signal

Frequency: Continuously adjustable from 5 KHz to 500 KHz; accuracy, ±5% of setting; internally supplied

Level: Continuously adjustable from less than 1 millivolt to approximately 3 volts

DC Bias

Internally supplied only; continuously adjustable from −5 volts to +100 volts

Primary Power

105/125 V, 50/60 Hz, 65 W; 210/250 V, 50/60 Hz version also available at no additional cost

Physical Specifications

In cabinet, 13″ h x 19½″ w x 14⅞″ d overall
Rack-mounted, 12¼″ h x 19″ w, panel size; 12⅜″ behind rack
Weight, 39 lbs. in cabinet; 32 lbs., rack

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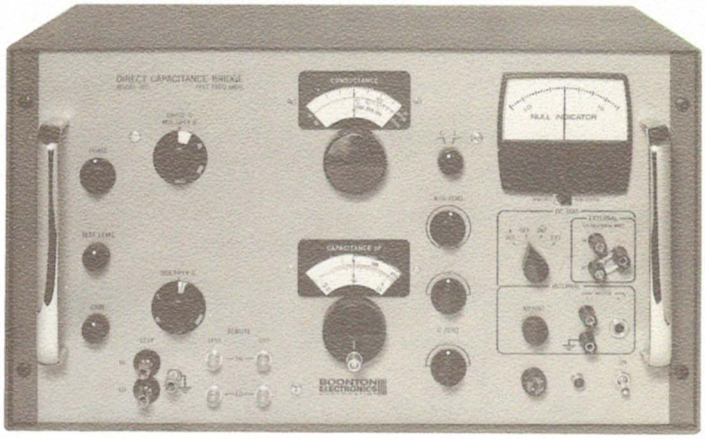
BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY

Model 75D 1 MHz Capacitance Bridge

A New 3-Terminal Capacitance Bridge Providing High Resolution Measurements Down to Low Values

- Capacitance measurements from 0.00005 pF to 1000 pF; basic accuracy, 0.25%
- Conductance measurements from 0.01 μmho to 1000 μmhos or resistance measurements from 1000Ω to 100 MΩ; basic accuracy, 5%
- Measurements of effective inductance from 25 μH to ∞
- Phase sensitive detector permits capacitance or inductance measurements independent of loss
- Accurate measurements of extremely low Q devices
- High capacitance resolution with low test signal levels
- Particularly valuable for semiconductors
- Remote measurements via coaxial cables



- Internal dc bias; dual external bias
- Provision for differential or comparison measurements
- No False or sliding nulls
- Completely self-contained, including bridge circuitry, crystal controlled 1 MHz oscillator, both amplitude and phase sensitive detectors, and null indicator

Introduction

Model 75D provides capacitance and loss measurements over wide ranges with outstanding resolution and contains a number of refinements over the previous models that contribute to its accuracy, convenience of operation, and versatility.

Measurements Independent of Loss

An important feature of the Model 75D is the inclusion of a phase sensitive detector. Since this detector is insensitive to the conductive (resistive) component of the test, capacitance (or inductance) measurements can be made by adjustment of the capacitance control only, greatly speeding the balancing operation. In the "Phase" mode, the resolution of the bridge is an order of magnitude greater than in the "Amplitude" mode, for a given test level. In the phase mode, the null indicating meter is connected for zero-center reading, with the polarity of deflection indicating the direction of the capacitance unbalance.

Measurement Including Loss

Using the amplitude detector, the capacitance (or inductance) and conductance of the test are balanced and measured in the conventional fashion. In the amplitude mode, the null indicator is switched for zero-left reading.

In either phase or amplitude mode, the bridge is free of false nulls or sliding balance.

Test Signal Adjustable to Low Levels

The crystal controlled 1 MHz test signal is continuously adjustable from a maximum of 250 millivolts to a practical minimum of approximately 1 millivolt in the Amplitude mode, and to approximately 15 millivolts in the phase mode.

DC Bias

The Model 75D is equipped for both dual external dc bias and single internal dc bias. Externally supplied bias voltages appear between HI post and ground and/or the LO post and ground, wholly independently of each other. Maximum allowable differential between HI and LO posts, or between either post and ground is ± 400 V @ 100 mA.

Internally supplied dc bias appears between HI and LO posts

only, and is continuously adjustable from —6 V to +150 V. Front panel jacks are provided for monitoring both internal bias voltage and current.

Differential or Comparison Measurements

The standard arm of the bridge is accessible through front panel BNC connectors so that external standards or balancing capacitors can be attached. This is valuable where very high resolution of larger values of capacitance is required. Combined with the excellent long term stability of the Model 75D, this facility makes the instrument particularly valuable for such studies as the determination of temperature coefficients.

Remote Measurements

The three-terminal arrangement of the Model 75D permits locating the test specimen remotely from the TEST terminals, since the bridge is essentially insensitive to impedances from either side of the test to ground. As a result the capacitance of the connecting cables can be ignored and errors resulting from changes in cable position or cable temperature are eliminated. The characteristics of the specimen alone may be accurately measured even when the specimen and connection system are exposed to wide temperature variations, to vibration, or to other extreme environmental conditions.

Inductance Measurements

Setting the front panel C/L selector in the L position reverses connections to the conductance balance network, permitting determination of effective inductance in terms of "negative capacitance". In this case, the reading from the capacitance dial is the resonating capacitance and, when submitted to simple computation, yields the effective inductance of the test. Inductance measurements are possible in either the phase or amplitude mode.

SPECIFICATIONS

Capacitance Range: 0 to 1000 pF

Capacitance Accuracy and Resolution:

Multiplier	Range, pF	Resolution Phase Mode, pF	Resolution Amplitude Mode, pF	Accuracy Phase Mode	Accuracy Amplitude Model
1.0	0 to 1000	0.2	0.2	$\pm[(0.25 + 10/Q)\% + 0.5\ pF]$	$\pm[(0.25\% + (1000/R_p + 0.5)\ pF]$
0.1	0 to 100	0.02	0.02	$\pm[(0.25 + 3/Q)\% + 0.05\ pF]$	$\pm[(0.25\% + (1000/R_p + 0.05)\ pF]$
0.01	0 to 10	0.002	0.002	$\pm[(0.25 + 3/Q)\% + 0.005\ pF]$	$\pm[(0.25\% + (1000/R_p + 0.005)\ pF]$
0.001	0.05 to 1	0.0002	0.0005	$\pm[(0.25 + 3/Q)\% + 0.001\ pF]$	$\pm[(0.25\% + (1000/R_p + 0.001)\ pF]$
0.001	0 to 0.05	0.0002	0.0005	$\pm[(2 + 3/Q)\% + 0.0002\ pF]$	$\pm[(2\% + (1000/R_p + 0.0002)\ pF]$
0.0001	0 to 0.1	0.00005	0.0005	$\pm[(2 + 10/Q)\% + 0.00005\ pF]$	$\pm[(2\% + (1000/R_p + 0.00005)\ pF]$

where R_p is the equivalent parallel resistance of the test in ohms

Inductance Range (Effective Inductance): 25 μH to infinity; basic accuracy, 0.25%

Conductance Range: 0 to 1000 μmhos (Amplitude Mode only)

Conductance Accuracy and Resolution:

Divider	Range	Accuracy	Resolution
1000	0 to 1 μmho	$\pm(5\% + Q/500\% + 0.01\ \mu mho)$	0.01 μmho
100	1 to 10 μmhos	$\pm(5\% + Q/500\% + 0.1\ \mu mho)$	0.05 μmho
10	10 to 100 μmhos	$\pm(5\% + Q/500\% + 1\ \mu mho)$	0.5 μmho
1	100 to 1000 μmhos	$\pm(10\% + Q/500\% + 10\ \mu mhos)$	5 μmhos

Resistance Range: 1000Ω to 100 MΩ (Amplitude Mode only)

Resistance Accuracy and Resolution:

Multiplier	Range	Accuracy	Resolution
1000	1 MΩ to 100 MΩ	$\pm(5\% + Q/500\% + R/10^6\%)$	$R/10^6$
100	100 KΩ to 1 MΩ	$\pm(5\% + Q/500\% + R/10^5\%)$	$R/10^5$
10	10 KΩ to 1 MΩ	$\pm(5\% + Q/500\% + R/10^4\%)$	$R/10^4$
1	1 KΩ to 100 KΩ	$\pm(10\% + Q/500\% + R/10^3\%)$	$R/10^3$

Where R is the resistance of the test in ohms

Test Signal:

Frequency, 1 MHz (±200 Hz), crystal controlled

Level, continuously adjustable from 1 mV to 250 mV

Dual External DC Bias: Appears between HI post and ground and/or LO post and ground independently. Maximum allowable differential from HI to LO post or from either post to ground, ±400 V @ 100 mA.

Internal DC Bias: Continuously adjustable from —6 V to +150 V.

Primary Power:

105-125, 50/60 Hz

210-250, 50/60 Hz As specified

Physical Characteristics:

Overall (in cabinet): 11¼" h x 19½" w x 12¾" d
Without Cabinet (for rack mounting): 10½" h x 19" w x 10⅛" d
Weight (with cabinet): 35 lbs.
Weight (without cabinet): 25 lbs.

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Printed in U.S.A. 5M 4/71 RP

BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY

Models 77B & 77B-S1 Automatic Capacitance Limit Bridges

Precision Three-Terminal Capacitance Limit Bridges for High-Speed, Automatic Go/No-Go Testing

- Capacitance Measurements:
  Model 77B (1MHz)
  Automatic Mode, 0.001 pF to 1000 pF
  Manual Mode, 0.0001 pF to 1000 pF
  Basic Accuracy, 0.25%

  Model 77B - S1 (100 KHz)
  Automatic or Manual Mode, 0.001 pF to 1000 pF
  Basic Accuracy, 0.1%

- Inductance Measurements:
  Model 77B (1 MHz)
  Automatic or Manual Mode, 25 μH to 25 mH
  Basic Accuracy, 0.25%

  Model 77B-S1 (100 KHz)
  Automatic or Manual Mode, 2.5 mH to 250 mH
  Basic Accuracy, 0.1%

- Conductance Measurements:
  Manual only, 0 to 1000 μmhos

- Resistance Measurements:
  Manual only, 1000 Ω to 100 MΩ

- Capacitance and inductance measurements wholly independent of the loss of the specimen

- Tolerance limits continuously adjustable from $\pm$0.0005 pF to $\pm$200 pF;

- Automatic test time approximately 50 milliseconds

- Visual and electrical test decision outputs

- Three-terminal arrangement permits remote measurements

- Internally supplied dc bias continuously adjustable from -6 to $+150$ V; external bias to ± 400 V

- Internally supplied, controlled test signal continuously variable from 250 mV down to 1 mV

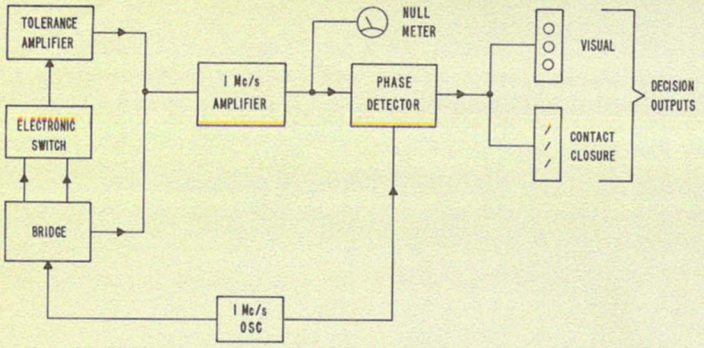

Figure 1 Block diagram of the Models 77B & 77B-S1

GENERAL DESCRIPTION

The Models 77B and 77B-S1 bring the precision and high resolution of meticulous bridge measurements to automatic high-speed dual or single limit capacitance testing. The two instruments are essentially similar except for test frequency, the Model 77B operating at 1 MHz and the Model 77B-S1, at 100 KHz.

In the automatic mode any nominal value from 0.001 pF to 1000 pF and any tolerance from ±0.0005 pF to ±200 pF may be programmed for rapid go/no-go capacitance tests. Automatic inductance limit tests may be made with inductance limits continuously adjustable from 0 to at least ±20% of nominal. Test decision outputs are provided in visual form by indicator lamps as well as in electrical form for actuation of external equipment.

In the manual mode the instruments operate as conventional laboratory bridges, providing direct reading measurements of capacitance, parallel resistance, and conductance. Inductance may also be determined by simple computation.

The test signal is internally supplied and is continuously adjustable from 250 millivolts to 15 millivolts for limit testing and to 1 millivolt for manual measurements.

Both the 1 MHz test oscillator of the Model 77B and the 100 KHz generator of the Model 77B-S1 are crystal controlled.

Test specimens may be biased either by the internal regulated dc supply whose output is continuously adjustable from −6 to +150 volts or by an external supply up to ±400 volts.

The three terminal arrangement permits remote measurements since the bridge is essentially insensitive to impedances from either side of the test to ground. The test specimen may be connected to the bridge by coaxial cables without incurring errors due to cable capacitance.

The standard arm of the bridge is accessible by means of front panel BNC connectors so that external standards or balancing capacitors may be attached. Thus these instruments may be used as comparison bridges or for differential measurements.

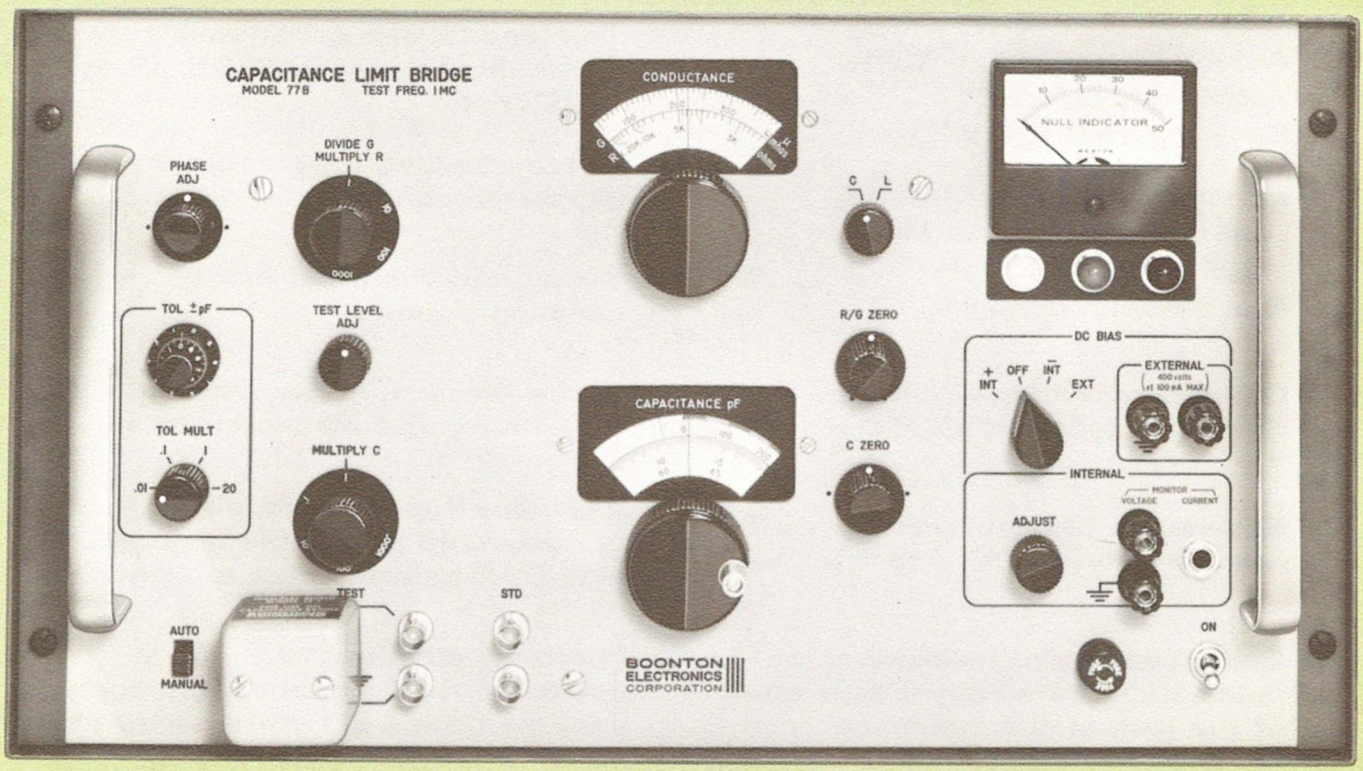

Figure 2. Front panel view of Model 77B

The Models 77B and 77B-S1 (including bridge and limit circuitry, test oscillator, null detector, bias supply, and decision outputs) are packaged as single bench type units. When removed from the case, they may be mounted in a standard 19-inch rack.

THEORY OF OPERATION

A simplified block diagram of the Models 77B and 77B-S1 is shown in Figure 1.

Bridge Circuit — The basic bridge network is a modified Young circuit, essentially similar to that used in the Boonton Electronics Models 75A and 75D 1 MHz Capacitance Bridges. The main capacitance balance control operates a variable differential air capacitor. Use of a differential air capacitor here contributes to the overall bridge stability since the capacitive elements in each arm are subjected to identical thermal conditions.

Great care is taken in the design of the main balance capacitor, in its metallurgy, in the fabrication and assembly of its parts, and in its final adjustment to assure the highest degree of accuracy and stability within the limits of the state of the art. The unique design and construction of the mechanical linkage between this capacitor and its associated dial hold back-lash to a minimum, permitting full advantage to be taken of the excellent resolution capability of the bridge.

The capacitance range selector (MULTIPLY C) comprises a network of precisely adjusted, gold plated invar capacitors. The conductance control (calibrated also in parallel resistance) is a specially selected long-life potentiometer.

Since the capacitance and conductance balancing networks are essentially independent of each other, the range setting for one parameter has no bearing on the setting of the other. In addition, this lack of interaction between the capacitance and conductance arms assures convenient, straightforward balancing without the annoyance or ambiguity of false nulls or "sliding" balance.

Phase Sensitive Null Detector — An outstanding feature of these bridges is the phase sensitive null detector. A portion of the test signal is applied to the detector to establish the reference voltage. Just as the bridge passes through balance, the phase of the bridge output abruptly shifts 180 degrees. Thus the bridge output either adds to (or subtracts from) the reference voltage depending on whether the capacitance of the **TEST** arm is greater or less than that of the **STANDARD** arm. At the precise point of balance, there is no output from the bridge, resulting in rapid switching between high and low test decisions.

Since the conductive (resistive) component of the test is 90 degrees out of phase with the capacitive (inductive) component, **its influence on the phase sensitive detector is negligible. Thus, capacitance tests are substantially independent of the loss of the specimen.** In practice this means that go/no-go capacitance or inductance tests may be made on specimens having widely differing losses without readjustment of the conductance control.

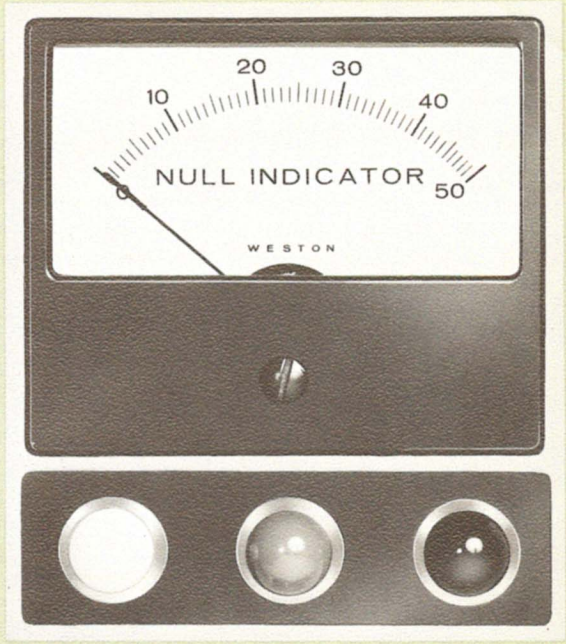

Figure 3. Detail of front panel showing null indicator and visual decision output lamps. Decision outputs in electrical form are available at rear panel terminals.

It should be noted that the Models 77B and 77B-S1 are also equipped with a conventional amplitude-sensitive null detector, permitting conductance/resistance measurements in the MANUAL MODE.

Manual Operation — With the mode selector set to MANUAL the models 77B and 77B-S1 are laboratory bridges of truly outstanding resolution.

In this mode the bridge is balanced and readings are taken in the conventional fashion. However, the phase sensitive detector provides a far more precise null indication than does a traditional amplitude-sensitive detector, particularly when working with low test signal levels; one may go from null (indicated by toggling of **both** Red and Yellow indicator lamps) to unmistakable "off balance" on either side (indicated by lighting of the red or yellow lamp alone) by turning the capacitance balance control **as little as 1/10 minor scale division.**

Automatic Limit Testing — With the mode selector switched to the AUTOMATIC position, the nominal is programmed by setting the MULTIPLIER C and main capacitance control for the desired value. Tolerance limits are established by adjusting a continuous control plus a four-position multiplier.

The electronic switch operating at line frequency samples the test signal voltage alternately at the standard arm and the test arm of the bridge, producing a voltage whose phase shifts 180° for each half switching cycle. This voltage is applied via the "Tolerance Amplifier" to the detector. The tolerance amplifier adjusts this signal level (by settings of the tolerance controls) to equal the unbalance voltage as seen by the detector that would be created in the bridge by a capacitance of the value of the programmed limit.

SPECIFICATIONS (Continued)

Conductance Measurement:

Range: Manual only; Range, 0 to 1000 μmhos

Divider	Conductance Range	Accuracy	Resolution
1	0 to 1000 μmhos	$\pm(10\% + \frac{Q}{500}\% + 10$ μmhos)	10 μmhos
10	0 to 100 μmhos	$\pm(5\% + \frac{Q}{500}\% + 1$ μmho)	1 μmho
100	0 to 10 μmhos	$\pm(5\% + \frac{Q}{500}\% + 0.1$ μmho)	0.1 μmho
1000	0 to 1 μmho	$\pm(5\% + \frac{Q}{500}\% + 0.01$ μmho)	0.01 μmho

Resistance Measurement:

Range: Manual only; 1000 Ω to 100 M Ω

Multiplier	Resistance Range	Accuracy†	Resolution
1	1KΩ to 100 KΩ	$\pm(10\% + \frac{Q}{500}\% + \frac{R}{10^3}\%)$	$\frac{R}{10^3}\%$
10	10KΩ to 1MΩ	$\pm(5\% + \frac{Q}{500}\% + \frac{R}{10^4}\%)$	$\frac{R}{10^4}\%$
100	100KΩ to 10MΩ	$\pm(5\% + \frac{Q}{500}\% + \frac{R}{10^5}\%)$	$\frac{R}{10^5}\%$
1000	1MΩ to 100MΩ	$\pm(5\% + \frac{Q}{500}\% + \frac{R}{10^6}\%)$	$\frac{R}{10^6}\%$

† Where R is the measured resistance in ohms

Test Signal

Frequency: 1 MHz (±200 Hz) crystal controlled
Level: Continuously adjustable from 1 mV to 250 mV

DC Bias

Internal: Continuously adjustable from —6 V to +150 V
External: Up to ±400 V @ 100 MA

Automatic Test Time

Approx. 0.05 sec.

Test Decision Outputs

Visual: Green, red, and amber panel lamps indicating "go", "high", and "low", respectively

Electrical: Sample of Indicator lamp filament voltages (6.3 V at line frequency) at rear terminals

Continuity: Relay contact closures in conformance with test decision at rear terminals

Primary Power

105-125 V, 50/60 Hz or
210-250 V, 50/60 Hz; 55 W

Physical Characteristics

Overall (in cabinet): 11¼" h x 19½" w x 12¾" d
Without Cabinet (for rack mounting): 10½" h x 19" w x 10⅛" d
Weight (with cabinet): 35 lbs.
Weight (without cabinet): 25 lbs.

SPECIFICATIONS, MODEL 77B-S1

All Specifications for the Model 77B-S1 are identical to those of the Model 77B with the following exceptions:

Capacitance Range:

Both Limit and Manual: 0.001 pF to 1000 pF

Capacitance Resolution and Accuracy:

Multiplier	Capacitance Range	Resolution	Accuracy, Manual	Accuracy, C Nominal (Automatic)
1.0	0 to 1000 pF	0.2 pF	$\pm(0.1\% + \frac{1000}{R_p}$ pF + 0.2 pF)	$\pm[(0.1 + \frac{3}{Q})\% + 0.2$ pF]
0.1	0 to 100 pF	0.02 pF	$\pm(0.1\% + \frac{1000}{R_p}$ pF + 0.05 pF)	$\pm[(0.1 + \frac{3}{Q})\% + 0.05$ pF]
0.01	0 to 10 pF	0.002 pF	$\pm(0.1\% + \frac{1000}{R_p}$ pF + 0.01 pF)	$\pm[(0.1 + \frac{3}{Q})\% + 0.01$ pF]
0.001	0.05 to 1 pF	0.0002 pF	$\pm(0.1\% + \frac{1000}{R_p}$ pF + 0.002 pF)	$\pm[(0.1 + \frac{3}{Q})\% + 0.002$ pF]
0.001	0 to 0.05 pF	0.0002 pF	$\pm(2\% + \frac{1000}{R_p}$ pF + 0.0002 pF)	$\pm[(2 + \frac{2}{Q})\% + 0.0002$ pF]

* Where R_p is the equivalent parallel resistance of the test in ohms.

Inductance Range:

Both Limit and Manual Mode, 2.5 mH to 250 mH

Inductance Accuracy:

C MULTIPLIER	Inductance Range	Accuracy, Manual	Accuracy of L Nominal (Automatic)
1.0	2.5 mH to 25 mH	$\pm(0.1 + \frac{L}{10K} + \frac{40\,L}{R_p})\%$	$\pm(0.1 + \frac{3}{Q} + \frac{LmH}{100})\%$
0.1	25 mH to 250 mH	$\pm(0.1 + \frac{L}{50K} + \frac{40\,L}{R_p})\%$	$\pm(0.1 + \frac{3}{Q} + \frac{LmH}{500})\%$

** Where L = millihenries
R_p = ohms of parallel resistance

Test Signal

Frequency: 100 KHz (±20 Hz, crystal controlled
Level: Continuously adjustable from 1 mV to 250 mV

Primary Power

105-130 V, 60 Hz
105-130 V, 50 Hz
210-260 V, 60 Hz
210-260 V, 50 Hz
} As specified

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Since the phase of the tolerance voltage alternates 180°, the result is the same as though the programmed capacitance limit value were switched first into the standard arm and then into the test arm of the bridge with the capacitance limit value "synthesized" electronically it is possible to program tolerances remotely without the use of external capacitors or complicated mechanical linkages; complex "zoning" of components may be readily accomplished.

The process of limit testing may be explained by considering the following example: Assume that 100 pF capacitors are to be tested to ±5%. The nominal value is established by setting the MULTIPLIER C selector to X1 and the main capacitance control to exactly 100 pF. The tolerance adjustment is set to ±5 pF.

Let us also assume that a specimen placed in the test fixture has an actual value of 93 pF. The tolerance amplifier applies a signal to the detector, equivalent to the addition of 5 pF to the **Standard Arm** for a total of 105 pF. With only 93 pF in the **Test Arm,** the bridge does not reach balance, the phase of the bridge output does not reverse, and the phase-sensitive detector issues a "Low" decision to the indicating circuitry. During the second half of the test cycle, output from the tolerance amplifier is equivalent to the addition of 5 pF to the **Test Arm** for a total of 98 pF, which still does not balance the bridge, and again a "Low" decision is issued.

If the actual value of the test sample were greater than 105 pF, the process would be the same, except that the bridge would pass through and beyond balance (and the phase of the bridge output would reverse) for **both** halves of the test cycle and the "High" indicator would remain lighted during the full cycle.

For a test specimen having a capacitance within the limits of 95 and 105 pF, with the 5 pF tolerance value added to the standard arm, the bridge would not reach balance and there would be no phase inversion. But with the 5 pF added to the Test Arm, the bridge would pass **through** balance for a "High" decision.

When the decision output of the phase sensitive detector shifts from "High" to "Low" on each successive half cycle, special circuitry disables the "High" and "Low" indicators, activating only the "Go" indicator. The complete dual-limit test cycle requires only 0.05 second.

Both the accuracy and resolution of nominal-value programming are comparable to the instrument's measuring capability, as specified on page 6. Limit values from ±0.0005 pF to ±200 pF may be set with resolution of 0.0001 pF or 1%, whichever is greater.

Test results are indicated by red, yellow, and green panel lamps representing "High," "Low," and "Go" decisions, respectively. Three contact closures (one for each test result) with floating common connection are provided at a rear panel. A sample of the 6.3 V, line frequency, filament voltage to each of the three indicating lamps is also provided at this panel. These electrical and continuity contacts may be used simultaneously for remote indications, or for control of external equipment.

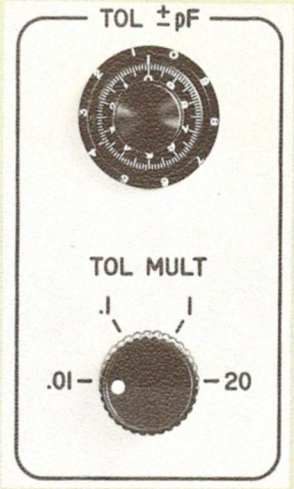

Figure 4. Tolerance limits, set at front panel controls, are continuously adjustable from zero to ±200 pF.

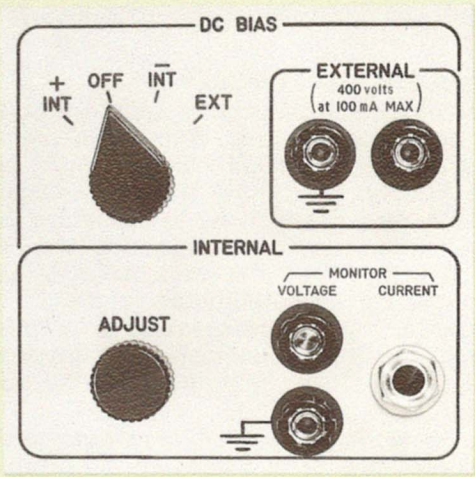

Figure 5. Detail of front panel showing dc bias controls. Provision for both internal and external dc bias is standard on both the Model 77B and Model 77B-S1.

Figure 6. The Model 77-1A Remote Test Jig is available as a separate accessory.

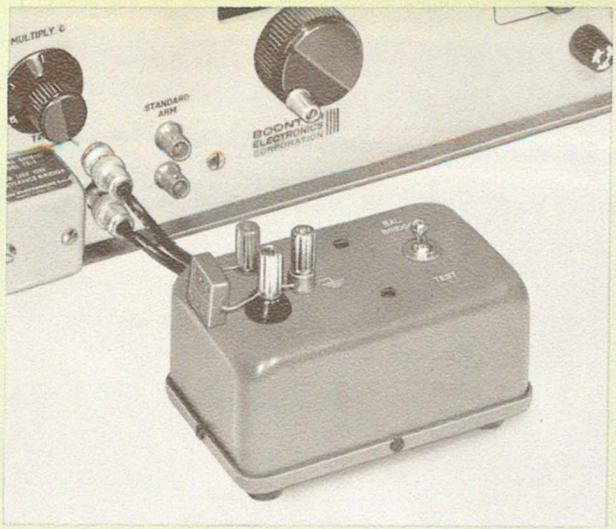

Figure 7. The Range Extender connects conveniently to the test terminals of the bridge to increase the instrument's range of measurement.

INDUCTANCE MEASUREMENTS

Equivalent parallel inductance can be measured on the Model 77B over a range from 25 microhenries to infinity, and, on the Model 77B-S1, from 2.5 millihenries to infinity. By turning the C/L selector to L, which reverses connections to the main conductance potentiometer, and connecting the specimen to the Standard Arm, the inductance is measured in terms of its resonating capacitance. Conversion from the capacitance reading to the effective parallel inductance is accomplished by simple computation, as detailed in the instrument's instruction book.

In the "L" Mode, either Manual or Automatic operation is available. Limit values are adjustable up to at least ±20% of nominal over the instrument's total inductance range.

AVAILABLE ACCESSORIES

Model CS Capacitance Standards — Available in any value from 0.01 pF to 1000 pF; Basic accuracy, 0.1%; designed for operation from 1 KHz to 1 MHz; calibrated against references traceable to National Bureau of Standards.

Model 77-1A Remote Test Fixture — Convenient test fixture connects to the TEST terminals of the bridge by coaxial cables; green, amber, and red lamps on jig duplicate front panel decision outputs; supplied complete with connecting cable for decision outputs and both magnetic and spring-loaded holders for components.

Model 77-2A Range Extender† — Precision ratio network attaches to test terminals of bridge to increase capacitance range to 0.1 μF, conductance range to 1 mho, resistance range to 1 ohm, and inductance range to 0.25 μH. Bridge accuracy is effectively unchanged and all biasing facilities are unaffected. The Model 77-2A is for use with the Model 77B in the MANUAL mode only.

Model 77-3A Range Extender† — Identical to the Model 77-2A except intended for use with 100 KHz bridges; used with Model 77B-S1, extends capacitance range to 1 μF, conductance range to 1 mho, resistance range to 1 ohm, inductance range to 2.5 μH; for MANUAL mode only.

SPECIFICATIONS, MODEL 77B

Capacitance Range:

Automatic: Nominal value continuously programmable from 0.001 pF to 1000 pF

Manual: Measures from 0.0001 pF to 1000 pF

Capacitance Resolution and Accuracy:

Multiplier	Capacitance Range	Resolution	Accuracy, Manual	Accuracy, C Nominal (Automatic)
1.0	0 to 1000 pF	0.2 pF	$\pm\left[0.25\% + \frac{1000}{R_p}\text{ pF} + 0.5\text{ pF}\right]$	$\pm\left[(0.25 + \frac{3}{Q})\% + 0.5\text{ pF}\right]$
0.1	0 to 100 pF	0.02 pF	$\pm\left[0.25\% + \frac{1000}{R_p}\text{ pF} + 0.02\text{ pF}\right]$	$\pm\left[(0.25 + \frac{3}{Q})\% + 0.05\text{ pF}\right]$
0.01	0 to 10 pF	0.002 pF	$\pm\left[0.25\% + \frac{1000}{R_p}\text{ pF} + 0.005\text{ pF}\right]$	$\pm\left[(0.25 + \frac{3}{Q})\% + 0.005\text{ pF}\right]$
0.001	0 to 1 pF	0.0002 pF	$\pm\left[0.25\% + \frac{1000}{R_p}\text{ pF} + 0.001\text{ pF}\right]$	$\pm\left[(0.25 + \frac{3}{Q})\% + 0.001\text{ pF}\right]$
0.0001	0 to 0.1 pF	0.0001 pF	$\pm\left[2\% + \frac{1000}{R_p}\text{ pF} + 0.00005\text{ pF}\right]$	———

* Where R_p is the equivalent parallel resistance of the test in ohms.

Capacitance Limits:

Range: Tolerance limits continuously programmable from ±0.0005 pF to ±200 pF

Accuracy of Limit Setting: ±1% of limit setting or ±0.0001 pF, whichever is greater

Inductance Range:

Automatic or Manual: 25 μH to 25 mH

Inductance Accuracy:

C MULTIPLIER	Inductance Range	Accuracy, Manual	Accuracy of L Nominal (Automatic)
1.0	25 μH to 250 μH	$\pm(0.25 + 2L + \frac{4000\,L}{R_p})\%$	$\pm(0.25 + \frac{3}{Q} + 2L)\%$
0.1	250 μH to 2.5 mH	$\pm(0.25 + \frac{L}{10} + \frac{4000\,L}{R_p})\%$	$\pm(0.25 + \frac{3}{Q} + \frac{L}{5})\%$
0.01	2.5 mH to 25 mH	$\pm(0.25 + \frac{L}{50} + \frac{4000\,L}{R_p})\%$	$\pm(0.25 + \frac{3}{Q} + \frac{L}{50})\%$

** Where L = millihenries
R_p = ohms of parallel resistance

Inductance Limits:

Range: Tolerance limits continuously adjustable from effectively zero to at least ±20% of inductance nominal

Accuracy of Limit Setting: Approx. 1% of limit value

(Specifications continued next page)

BOONTON ELECTRONICS CORPORATION
PARSIPPANY, NEW JERSEY

Model 91C Sensitive RF Voltmeter

A Reliable, Economical Meter for RF Voltage Measurements Over a Wide Frequency Range

- Voltage capability: 1 mV to 300 V*
- Frequency capability: 20 KHz to 1200 MHz; uncalibrated response beyond 4000 MHz
- Basic accuracy: 5%
- True rms response up to 3 V*
- VSWR less than 1.2 at 1200 MHz
- High input impedance
- Negligible noise

* With appropriate accessory; see text

GENERAL DESCRIPTION

The Model 91C is a practical, economical instrument for rf voltage measurements where the ultimate in sensitivity and precision is not required. It provides reliable, highly reproducible measurements from 20 KHz to 1200 MHz, and useful relative measurements (for null and peak indications for example) beyond 4000 MHz. (For measurements beyond approximately 600 MHz, the accessory Model 91-14A Tee Adapter and 91-15A 50-ohm Termination are required and should be ordered as separate items. See accessory listings on reverse side.)

The Model 91C offers true rms response with input levels up to 30 millivolts (to 3 volts with the accessory 100:1 Voltage Divider). The instrument is characterized by high input impedance (see curves on reverse side), excellent stability, and low noise.

Two voltage scales (calibrated 1 to 3 and 3 to 10) display the seven ranges of sensitivity. A dB scale calibrated 0 to 11 is also provided. A dBm (50 ohm) scale may be selected as an alternate version at no additional cost.

Standard equipment supplied with the Model 91C includes: an RF Probe with specially designed low noise cable and connector assembly; removable Probe Tip with alligator-clip grounding lead; and a 50 ohm BNC Adapter.

THEORY OF OPERATION

The Model 91C consists essentially of a detector probe, a highly sensitive, stable, chopper type dc amplifier, and a voltmeter.

The RF Probe embodies a full-wave diode rectifier which provides **true rms** response for input levels up to approximately 30 millivolts. As the input voltage increases beyond this level, response gradually approaches peak-to-peak (calibrated on the meter scale in rms). The full-wave rectification provided by the diode detector eliminates errors resulting from turnover effect.

The rectifier output from the probe, after passing through an attenuator network (range selector), is converted to 60 Hz ac by a low noise chopper. It is then fed to the feed back stabilized amplifier. The 60 Hz output from the amplifier is rectified by a voltage doubler and passed through a diode network to convert the non-linear response of the rf probe to a linear current suitable for metering.

APPLICATIONS

In addition to voltage measurements and related tests in a variety of rf circuits, the Model 91C is valuable for such applications as the measurement of high frequency characteristics of transistors and other semiconductor devices; determining the frequency response of both active and passive networks; measurement of vswr and return loss in transmission lines and attenuator systems; measurement of broad band noise; and proper alignment of rf filters, in addition to determining their characteristics.

SPECIFICATIONS

Voltage Measuring Range: 1 mV to 3 V (to 300 V with accessory 100:1 Voltage Divider)

Full Scale Volts: 3 mV to 3 V; 7 ranges in a 3-10-30 sequence

Frequency Range: 20 KHz to 1200 MHz; uncalibrated response for relative measurements beyond 4000 MHz

Accuracy: ±5% fs from 50 KHz to 400 MHz
±10% fs from 20 KHz to 50 KHz and from 400 MHz to 1200 MHz

Noise: Sensibly zero on all ranges

DB Range: 70 dB (60 dB in 10 dB switch steps plus 10 dB on meter scale)

Waveform Response: True rms with input levels up to 30 mV (or 3 V with accessory 100:1 Voltage Divider); gradually changes to peak-to-peak reading (calibrated in rms) at higher levels

Crest Factor: 42 to 1.4, depending on input level

Power Sensitivity: 0.02 microwatt, max.

VSWR: Less than 1.2 up to 600 MHz with 91-8B 50 Ω Adapter; less than 1.2 up to 1200 MHz in 50 Ω system with 91-14A Tee Adapter and 91-15A 50 Ω Termination

Accessories Provided: Model 91-12E RF Probe; Model 91-13B Probe Tip; Model 91-8B 50 ohm BNC Adapter

Primary Power: 105/125 V, 60 Hz; 35 watts; 210/250 V, 50 Hz available at no extra cost

Mechanical Specifications: 7¼" w x 10¼" d x 11" h (excluding leather carrying handle); net weight 12 lb.; packed for shipment, 16 lbs.

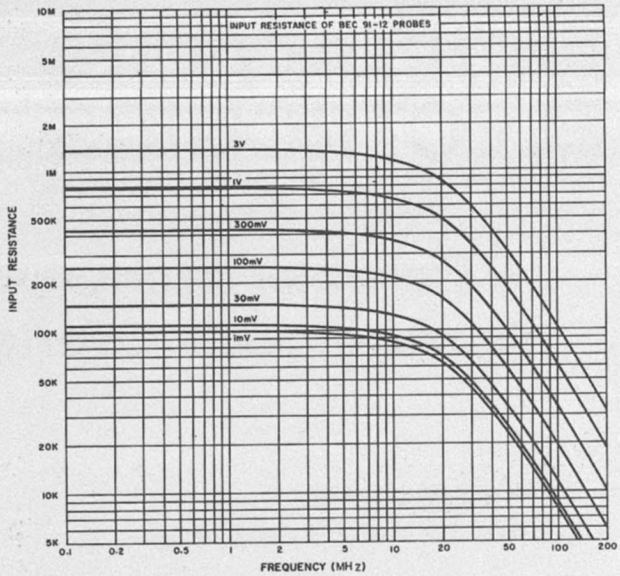

Figure 1. Input resistance, 91-12 RF Probe

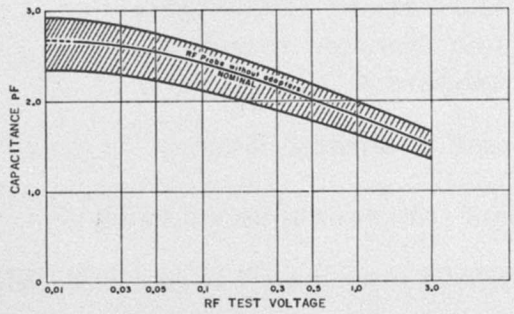

Figure 2. Input capacitance vs. test level (Measured at 10 MHz)

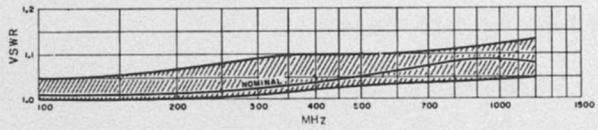

Figure 3. Typical vswr of 91-12 RF Probe with 91-14 type "N" Tee Adapter terminated in a 91-15 50Ω Termination

Model 91C: 117 v, 60 Hz, only
Model 91C-S4: 117 v, 50 to 400 Hz
Model 91C-S5: 117 v, 60 Hz only, with dBm scale
Model 91C-S7: 117 v, 50 to 400 Hz, with dBm scale

Rack Mounting Versions, Model 91CR

OTHER BOONTON ELECTRONICS RF VOLTMETERS

Model 91H: Voltage capability, 100 μV to 300 V; frequency capability, 20 KHz to 1200 MHz, with uncalibrated response beyond 4000 MHz; Basic accuracy, 3%

Model 91DA : With basic acuracy of 2%, this is the most accurate RF Voltmeter commercially available; voltage capability, 300 μV to 300 V; frequency capability, 20 KHz to 1200 MHz, with uncalibrated response beyond 4000 MHz.

AVAILABLE ACCESSORIES

The following accessories are available for use with the Model 91C and should be ordered as separate items:

Model 91-4C RF Probe for low frequency (1 KHz to 250 MHz) operation

Model 91-6C Unterminated BNC Adapter

Model 91-7C 100:1 Voltage Divider; attenuates input signal by a factor of 100 (±1%); permits measurement of amplitudes up to 300 V; increases rms response range to 3 V; frequency range, 50 KHz to 700 MHz

Model 91-14A Type N Tee Connector; permits connection into 50 ohm coaxial line; required for measurements within specified accuracy above approximately 600 MHz; vswr less than 1.2 to 1200 MHz

Model 91-15A 50 ohm Termination required for use of Model 91-14A

Model 91-16A Unterminated Type N Adapter

ROUTE 287 AT SMITH RD., PARSIPPANY, N.J. 07054 · TEL.: 201-887-5110 TWX: 710-986-8241

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BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY

Model 91DA Sensitive RF Voltmeter

A Sensitive Broadband Voltmeter with A Basic Accuracy of 2 Percent

- Voltage Range: 1 mV fs to 3 V* fs in 8 ranges
- Sensitivity: 300 μV
- Frequency Range: 20 KHz to 1.2 GHz; useful sensitivity above 4 GHz
- VSWR less than 1.2 to 1.2 GHz
- True rms response from 300 μV to 30 mV**
- Minimal zero adjustment; zero adjustment holds for all ranges
- High input resistance; low input capacitance
- Rapid response; no delay in reading
- Probe overload protected to 400 V, dc; to 10 V, rf
- DC recorder output

*To 300 V with Model 91-7C 100:1 Voltage Divider
**To 3 V with Model 91-7C 100:1 Voltage Divider

Introduction

The Model 91DA measures over a wide range of amplitude and frequency with a basic accuracy of 2 percent.

The instrument's fast response and excellent stability permit accurate, rapid measurements over extended periods without repeated interruptions for tedious readjustment, or delays before each test while the indicator comes to rest.

The high accuracy of the Model 91DA not only is valuable for general design, research, and inspection functions, but also permits its use as a transfer standard for calibrating a number of other, less accurate rf voltmeters against a single, reliable reference.

While the Model 91DA is a sensitive, accurate instrument, it is by no means delicate. It is sturdily constructed to perform over extended periods, not only in the laboratory, but also in the more demanding environments of field and production applications.

The Model 91DA is packaged as a compact, portable bench unit. A rack mounting version, the Model 91DA-R, is also available.

Both instruments are supplied with RF Probe and low noise cable, removable Probe Tip with grounding clip lead, and a 50 ohm BNC Adapter.

A complete kit of RF Voltmeter accessories is also available. It includes an Unterminated BNC Adapter, 100:1 Volt-

age Divider, Tee Connector, and 50 ohm Termination, as well as the RF Probe and 50 ohm Adapter & Probe Tip, all in a sturdy storage case. (See Accessories on last page for a full detailed description.)

Measurements from 300 microvolts to 3 volts

Eight ranges from 1 millivolt full scale to 3 volts full scale are arranged in 1-3-10 sequence. No attenuator attachments are required for measurements up to 3 volts. While this range is ample for the majority of rf voltage measurements, the capability of the Model 91DA can be increased to 300 volts (up to 700 MHz) by using the accessory Model 91-7C 100:1 Voltage Divider. Use of the 100:1 Voltage Divider also increases the input impedance of the Probe by a factor of approximately 1000.

Broad Frequency Range

The calibrated frequency range of the Model 91DA extends from 20 KHz to 1.2 GHz. Uncalibrated response, available beyond 4 GHz, is valuable for peak or null detection or other such relative measurements. Accuracy for relative indications above 1.2 GHz is typically ±0.5 dB.

A Model 91-8B 50 ohm BNC Adapter is provided with the instrument for operation in a 50 ohm system up to approximately 600 MHz. For measurements above 600 MHz the Models 91-14A Tee Connector and 91-15A 50 ohm Termination are required.

The Model 91DA can be used for measurements from 250 MHz down to 1 KHz through use of the Model 91-4C Low Frequency Probe. Details on its performance are given under "Accessories".

True RMS Response

The Model 91DA provides true rms response for signal inputs below approximately 30 millivolts (below 3 volts with the Model 91-7C 100:1 Voltage Divider). As the input level increases, waveform response gradually approaches peak-to-peak, calibrated on the meter scale in rms. Thus, in addition to making precise sinusoidal voltage measurements at all levels, the Model 91DA measures non-sinusoidal or asymmetrical signals within the rms region without loss of accuracy.

Low Noise

Extensive care is taken throughout the design and construction of the Model 91DA to hold noise from all sources to a minimum. On the most sensitive (0.001 V) range, indicator unrest is less than 2 percent full scale; on all other ranges it is sensibly zero.

The Probe cable is of special low noise design, and vigorous flexing causes momentary, minor deflections only on the most sensitive range. The RF Probe is not sensitive to shock or vibration; even sharp tapping on the probe barrel causes no visible deflection on any range.

Minimal Zero Adjustment

Zero adjustment is never required on the upper five sensitivity ranges of the Model 91DA. For measurements on the lower three ranges (0.001 V, 0.003 V, and 0.01 V) the "PRESS TO BAL" control is nulled prior to operation. This control balances out small thermal voltages in the probe elements, and once adjusted, it requires only infrequent checking during the course of subsequent measurements. This freedom from frequent or fussy zero adjustment is especially valuable in production testing where it permits measurements over extended periods without interruption.

Reliability of Measurement

The range over which the Model 91DA measures with 2 percent accuracy extends from 150 KHz to 100 MHz (except on the most sensitive range where, because of the possibility of errors resulting from thermal voltages or other low level phenomena, accuracy is specified as 4 percent). Above and below these frequency limits, accuracy is somewhat reduced as indicated in the table of specifications.

A number of other characteristics contribute to the reliability of measurement of the Model 91DA. For example, the exceptionally low capacitance of the RF Probe (less than 3 pF) and high input resistance minimize errors owing to loading effects.

The instrument is essentially insensitive to line voltage changes within its specified rating (105 V to 125 V or 210 V to 250 V). Even abrupt changes within these limits have no visible effect on the meter indication. The Model 91DA is also highly insensitive to local electromagnetic fields, and only in the most extreme cases must special precautions be taken to avoid the effects of stray pick up.

The long term stability of the instrument is such that drift is typically less than 0.5% of full scale in 24 hours after a half-hour warm-up.

Calibration of the Model 91DA is independent of source impedance.

Rapid Response

Response time of the indicating meter is less than 2 seconds from zero to full scale on any range. The rapid response of the Model 91DA greatly facilitates such operations as peak or null detection where the indicator must follow circuit adjustments promptly. Similarly, the fast response facilitates zero adjustment, and is essential in production testing or inspection where rapid, repetitive tests are required.

Additional Advantages

- The 6-inch mirrored scale meter has 1-to-3 and 3-to-10 voltage calibrations and 0-to-11 dB calibrations. A volt/dBm (50 ohm) scale may be selected as an alternate at no extra cost.
- A linear dc recorder output is available at front panel terminals; it provides at least 1 volt for full scale deflection on any range. The output can be used simultaneously with the indicating meter without interaction. Response time of the output is less than 0.5 second on the 0.001 V range, and less than 0.1 second on all other ranges.

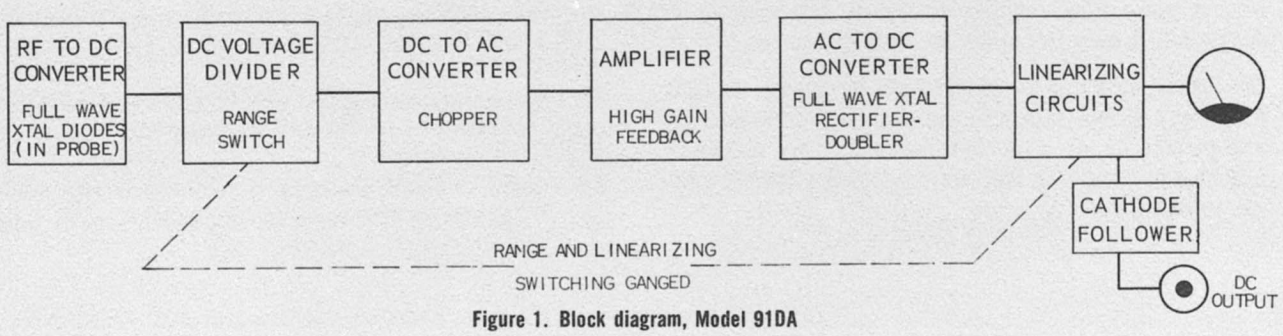


Figure 1. Block diagram, Model 91DA

- The RF Probe is protected against overload up to 400 V, dc and to 10 V, rms, ac.
- No spurious signal output issues from the RF Probe.
- No recalibration or other readjustment is required when switching from one probe accessory to another.

Theory of Operation

As can be seen from the block diagram of Figure 1, the Model 91DA comprises a solid-state detector probe, a highly stable chopper-type dc amplifier, a voltmeter, and dc output circuitry.

The rf voltage is applied through a dc blocking capacitor to a pair of high-frequency diodes connected for full-wave rectification.

The square-law characteristic of the diodes (for inputs below approximately 30 millivolts) plus the full wave configuration provide true rms response, eliminating the possibility of error resulting from waveform asymmetry, so long as the crest factor of the test voltage does not exceed that specified for the range employed (see table of specifications). As the input voltage increases beyond 30 millivolts, response gradually approaches peak-to-peak, calibrated on the meter scale in rms, continuing to give accurate rms reading of sinusoidal voltages up to 3 volts.

The dc output from the probe is passed through a voltage dividing network (range selector) where it is attenuated as required before being converted to ac at power line frequency by a low-noise mechanical chopper. The chopper output is applied to a narrow band feed-back stabilized ac amplifier. Filter networks at the amplifier input minimize ac and rf pick-up. The ac coupled amplifier stages assure drift-free performance.

Output from the amplifier is converted to dc by a voltage doubler and passed through a diode network to convert the non-linear response of the probe diodes to a linear current suitable for metering. Additional circuitry is included to allow expansion of the calibrated portion of the meter scale over the greatest area possible for maximum readability.

The dc recorder output is obtained from the linearizing network. It is isolated from the metering signal by balanced dc cathode followers and its use does not affect meter indications. The dc output offers approximately 1 volt into a 1000 ohm load for full scale deflection. A dc voltage applied to the grid of one of the cathode followers is adjustable by means of the front panel OUTPUT ZERO control to permit setting the output to zero with no rf signal input.

Model 91DA-R Rack Mounting RF Voltmeter

The Model 91DA-R provides all of the measuring capabilities of the Model 91DA in rack-mounting form. A duplicate input cable connector is installed at the rear of the Model 91DA-R so that input may be made either at the front panel or behind the rack. Mechanical specifications of the Model 91DA-R are given on the following page.

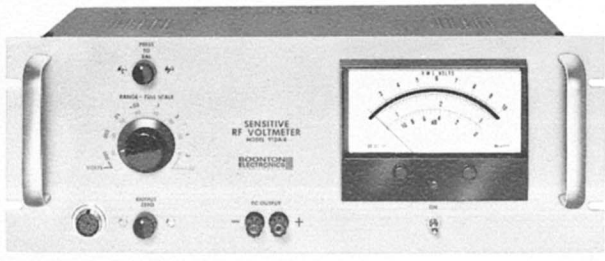


Figure 2. Model 91DA-R

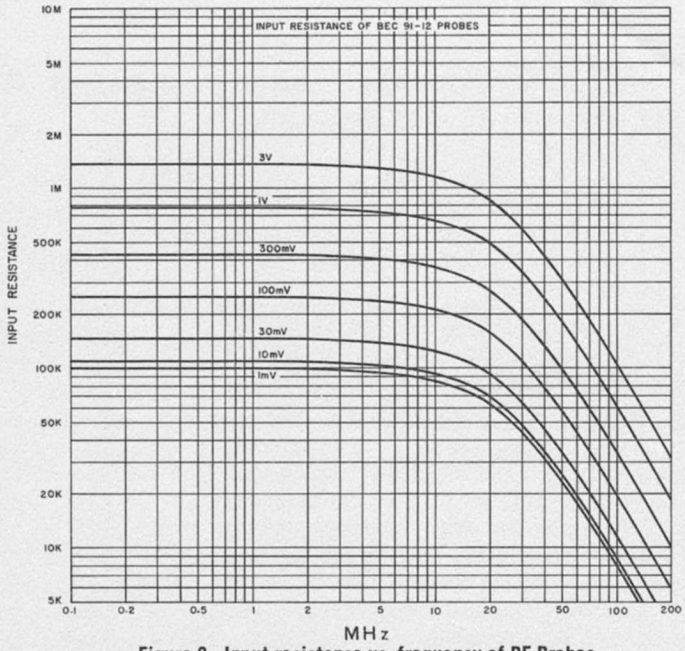


Figure 3. Input resistance vs. frequency of RF Probes for various input-levels

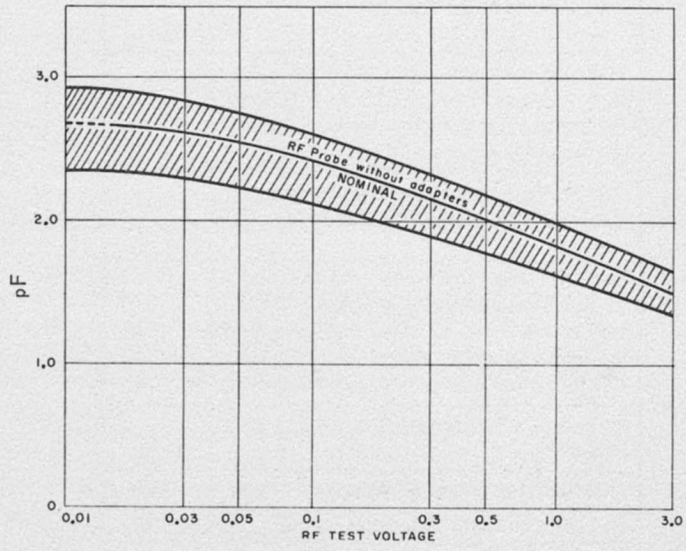


Figure 4. Input capacitance vs. input level of Model 91-12E RF Probe

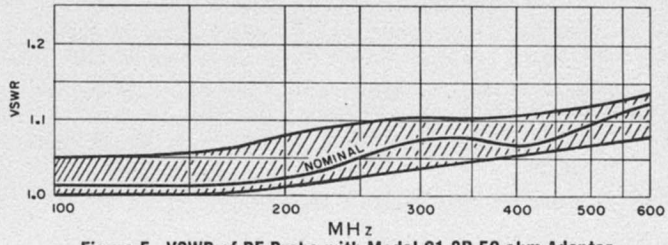


Figure 5. VSWR of RF Probe with Model 91-8B 50 ohm Adapter

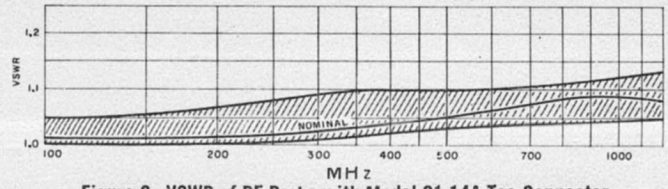


Figure 6. VSWR of RF Probe with Model 91-14A Tee Connector and Model 91-15A 50 ohm Termination

Accessories

Boonton Electronics offers a number of accessories which extend the utility of the Model 91DA:

Description	Model
Low Frequency Probe for measurements from 250 MHz down to 1 KHz; input resistance essentially the same as that of Model 91-12E	91-4C
Unterminated BNC Adapter for coaxial connection up to approximately 100 MHz or to 400 MHz when fed from a 50 ohm source in an electrically short system.	91-6C
100:1 Voltage Divider; attenuates input signal by a factor of 100 (±1%), permitting measurements up to 300 volts, and extending the rms measuring range to 3 volts; increases input resistance by a factor of 1000; operates from 50 KHz to 700 MHz. Maximum input potential, 1000 volts, dc plus peak ac.	91-7C
50 ohm BNC Adapter for measurements up to 600 MHz in a 50 ohm system; for vswr see curve of Figure 5;	91-8B
RF Probe with low noise cable and connector assembly for measurements from 20 KHz to 1200 MHz; see Figures 3 and 4 for input resistance and capacitance.	91-12E
Removable Probe Tip with grounding clip lead; for use up to approximately 100 MHz.	91-13B
Type N Tee Connector; with Model 91-15A Termination (see below) permits connection into 50 ohm line; required for measurements above approximately 100 MHz; for vswr see curve of Figure 6.	91-14A
Type N 50 ohm termination for use with Model 91-14A Tee Connector.	91-15A
Unterminated Type N Adapter	91-16A
Storage container for accessories:	91-18A

Accessory Options

The Model 91DA is available as follows:

Standard: with Model 91-12E Probe, Model 91-13B Probe Tip, and Model 91-8B 50 ohm Adapter.

Full Accessory Option: with Complete Standard Accessory Kit, which includes: Models 91-6C Unterminated BNC Adapter, 91-7C 100:1 Voltage Divider, 91-8B 50 ohm BNC Adapter, 91-12E RF Probe, 91-13B Probe Tip, 91-14A Tee Adapter, and 91-15A 50 ohm Termination, in the Model 91-18A Storage Container.

Accessories also available separately.

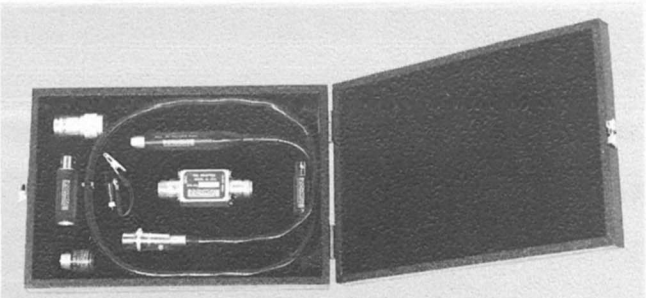


Figure 7. Complete Kit of RF Voltmeter Accessories

Specifications

Full Scale Volts: 0.001 V to 3 V; 8 ranges in 1-3-10 sequence

Voltage Sensitivity: 300 μV

dB Range: 81 dB (70 dB in 10 dB steps plus 11 dB on meter scale)

Power Sensitivity: 0.0018 μW

Accuracy: ±2% fs from 150 KHz to 100 MHz*
±5% fs from 50 KHz to 150 KHz and from 100 MHz to 400 MHz
±10% fs from 20 KHz to 50 KHz and from 400 MHz to 1.2 GHz
* ±4% fs on 0.001 V range

Noise: Indicator unrest is less than ±2% fs on 0.001 V range; sensibly zero on all other ranges

Indicator Response Time: Less than 2 seconds on all ranges

Waveform Response: True rms for inputs up to 30 mV, gradually approaching peak-to-peak (calibrated in rms) at higher levels

Crest Factor:

Voltage Range	0.001	0.003	0.01	0.03	0.1†	0.3†	1†	3†
Crest Factor	140 to 42	42 to 14	14 to 4.2	4.2 to 1.4	140 to 42	42 to 14	14 to 4.2	4.2 to 1.4

† With Model 91-7C 100:1 Voltage Divider

DC Recorder Output: Approx. 1 V into 1000 Ω load for full scale deflection; response time less than 0.5 second on 0.001 V range and less than 0.1 second on all other ranges

Line Voltage: 105/125 V, 60 Hz is standard. 105/125 V, 50 Hz; 230/250 V, 60 Hz; and 230/250 V, 50 Hz also available.

Power Consumption: 45 W

Mechanical Specifications:
Model 91DA: 7¼" w x 9½" d x 11" h; weight, 13½ lbs.
Model 91DA-R: 7" h x 19" w (panel size) x 8¾" behind rack; weight, 15 lbs.

Model	Description
91DA	RF Voltmeter with volt/dB scale
91DA-S5	RF Voltmeter with volt/dBm (50 Ω) scale
91DA-R	Rack-mounting RF Voltmeter with volt/dB scale
91DA-R-S5	Rack-mounting RF Voltmeter with volt/dBm (50 Ω) scale

specifications are subject to change without notice

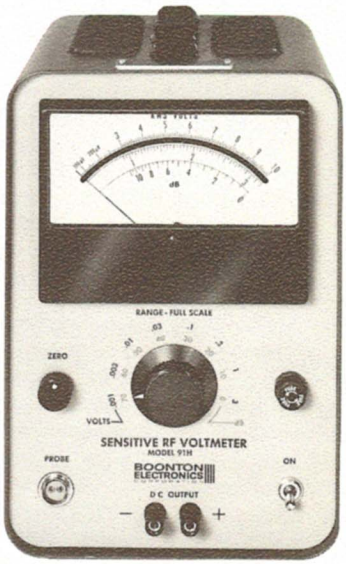
BOONTON ELECTRONICS CORPORATION
PARSIPPANY, NEW JERSEY

Model 91H Sensitive RF Voltmeter

An Accurate, Broadband RF Voltmeter Capable of Measuring Unusually Low Signal Levels

- Voltage capability, 100 μV to 300 V*
- Basic accuracy, 3%
- Calibrated response to 1200 MHz; Useful indications beyond 4000 MHz*
- Exceptionally low noise
- True rms response up to 3 V*
- VSWR less than 1.2 to 1200 MHz*
- High input impedance
- Linear dc output

* With appropriate accessory



General Description

The Model 91H is a highly sensitive rf voltmeter for measurement of signal levels from 3 volts[1] down to 100 microvolts over a frequency range from the low radio frequencies into the gigahertz region. The instrument provides true rms response with input levels up to 30 millivolts,[2] and is characterized by high input impedance, excellent stability, and low noise.

The calibrated frequency range of the Model 91H extends from 20 KHz to 1200 MHz. However, it should be noted that the instrument provides uncalibrated response for relative measurements such as detecting peaks of nulls beyond 4000 MHz. (Note: for operation beyond approximately 600 MHz, use of the accessory Model 91-14A Tee Adapter and Model 91-15A 50 ohm Termination is required, and they should be ordered as separate items; see accessory listing on reverse side.)

Two meter scales (calibrated 1 to 3 and 3 to 10) display the eight ranges of sensitivity. Subcalibrations of 100 microvolts and 200 microvolts are provided on the most sensitive range. A dB scale calibrated 0 to 11 is also included. A dBm (50 ohm) scale may be selected as an alternate version at no additional cost.

Standard equipment supplied with the Model 91H includes: an RF Probe with specially designed low noise cable and connector assembly; Probe Tip with alligator clip grounding lead; and a 50 ohm BNC Adapter.

A dc output is available at front panel terminals which is proportional to the meter reading. Jumper connections at a rear terminal board provide an output suitable for either display on a digital voltmeter (in which case the output may be adjusted for any full scale value from zero to 100 millivolts or 300 millivolts, depending on the numerics of the voltage range) or for application to a recorder (in which case the full scale output level is adjustable to any value from zero to 300 millivolts). Output resistance is 0 to 40,000 ohms, depending on output level.

1 To 300 volts with accessory 100:1 Voltage Divider
2 To 3 volts with accessory 100:1 Voltage Divider

Theory of Operation

The Model 91H comprises essentially a detector probe, a highly sensitive, stable, chopper type dc amplifier, and a voltmeter.

The RF Probe consists of a full wave diode rectifier which provides **true rms** response for input levels up to approximately 30 millivolts. As the input voltage increases beyond this level, response gradually approaches peak-to-peak (calibrated on the meter scale in rms).

The rectified output from the probe, after passing through an attenuator network (range selector), is converted to 60 hertz ac by a low noise mechanical chopper. It is then fed to the narrow band feed-back stabilized amplifier. The 60 hertz output from the amplifier is rectified by a voltage doubler and passed through a diode network to convert the non-linear response of the RF Probe to a linear current suitable for metering.

Great care has been taken in the design and construction of the Model 91H to hold noise, hum, and other sources of spurious deflection to a minimum. Jitter of the indicating needle on the most sensitive range (1 millivolt fs) is less than 2% fs, and sensibly zero on all other ranges. The probe cable of the Model 91H is of special low noise construction, and on the most sensitive range even vigorous flexing causes only momentary minor deflections.

Applications

The extremely high sensitivity and broad frequency range of the Model 91H suit the instrument for a great variety

of rf measuring functions. Beyond the usual voltage measurements and related tests in a variety of rf circuits, the Model 91H is valuable for such applications as the measurement of high frequency characteristics of transistors and other semiconductor devices; determining the frequency response of both active and passive networks; measurement of vswr and return loss in transmission lines and attenuator systems; determining the harmonic content of rf signals; measurement of broad band noise; and proper alignment of rf filters, in addition to determining their characteristics.

SPECIFICATIONS

Full Scale Volts: 1 mV to 3 V; 8 ranges in a 1-3-10 sequence

Voltage Measuring Range: 100 μV to 3 V (to 300 V with accessory 100:1 Voltage Divider)

Frequency Range: 20 KHz to 1200 MHz; useful indications beyond 4000 MHz. (Note: accessory Tee Adapter required for measurements beyond 600 MHz)

Accuracy:

±3% from 150 KHz to 100 MHz
±5% from 50 KHz to 150 KHz and from 100 MHz to 400 MHz
±10% from 20 KHz to 50 KHz and from 400 MHz to 1200 MHz

On most sensitive (1 mV, fs) range:
±5% from 150 KHz to 100 MHz
±10% from 50 KHz to 150 KHz and from 100 MHz to 400 MHz
±15% from 20 KHz to 50 KHz and from 400 MHz to 1200 MHz

Noise: Indicator unrest is less than 2% fs on most sensitive (1 mV fs) range; sensibly zero on all other ranges

dB Range: 80 dB (70 dB in 10 dB switch steps plus 10 dB on meter scale)

Waveform Response: True rms for input levels up to 30 mV (or 3 V with accessory 100:1 Voltage Divider) gradually changing to peak-to-peak reading (calibrated in rms) at higher levels

Crest Factor: 420 to 1.4, depending on input level

Power Sensitivity: 0.0002 microwatt, max.

VSWR: Less than 1.2 up to 600 MHz with 50 Ω Adapter; less than 1.2 up to 1200 MHz in 50 Ω system with Tee Adapter and 50 Ω Termination

Linear DC Output: Proportional to meter reading
"DVM" Mode, fs values continuously adjustable from 0 to 100 mV or 300 mV, depending on range numerics
"REC" Mode, fs value continuously adjustable from 0 to 300 mV for all ranges
Output Resistance, **0 to 40** KΩ, depending on output level

Accessories Furnished:

Model 91-12E RF Probe with low noise cable and connector assembly
Model 91-13B Probe Tip
Model 91-8B 50 Ohm BNC Adapter (other impedances available.

Primary Power: 105-125 V, 58 to 62 Hz; 35 W;
for special power requirements see below.

Mechanical Specifications: 7¼" w x 10¼" d x 11" h (excluding leather carrying handle); net weight, 12 lb.; packed for shipment, 16 lbs.

Models:

Model 91H: 105 V to 125 V, 58 to 62 Hz only*
Model 91H-S4: 105 V to 125 V, 50 to 400 Hz
Model 91H-S5: Same as 91H, with dBm scale
Model 91H-S7: Same as 91H-S4, with dBm scale

* Models for 105 V to 125 V, 48 to 52 Hz only, and 210 V to 250 V, 48 to 52 Hz only are available.

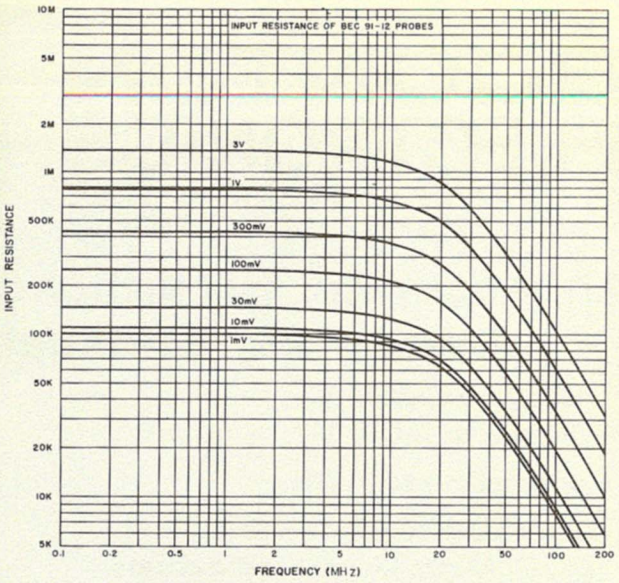


Figure 1. Input resistance, 91-12 RF Probe

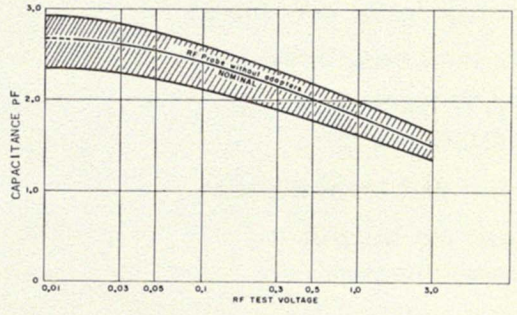


Figure 2. Input capacitance vs. test level (Measured at 10 MHz)

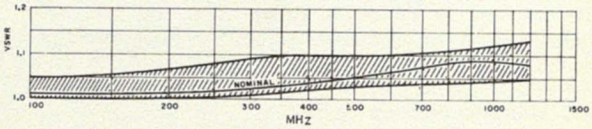


Figure 3. Typical vswr of 91-12 RF Probe with 91-14 type "N" Tee Adapter terminated in a 91-15 50Ω Termination

Accessories Available

Model No.	Description
91-4C	RF Probe for 1 KHz to 250 MHz operation
91-6C	Unterminated BNC Adapter
91-7C	100:1 Voltage Divider; attenuates input signal by a factor of 100 (±1%); permits measurements up to 300 V; increases range of rms response to 3 V; Frequency range, 50 KHz to 700 MHz
91-14A	Type N Tee Connector; permits connection into 50 ohm coaxial line; required for measurements within specified accuracy beyond 600 MHz; vswr less than 1.2 to 1200 MHz; requires 91-15A 50 ohm termination
91-15A	50 ohm Termination; required with 91-14A
91-16A	Unterminated Type N Adapter

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BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY

Model 91K
High Impedance RF Millivoltmeter

An Accurate, Broadband RF Millivoltmeter with Exceptionally High Input Impedance

- ☐ Voltage capability, 1 mV to 300 V*
- ☐ Input impedance greater than 4 MΩ
- ☐ Basic accuracy, ±3%
- ☐ Calibrated response from 0.5 MHz to 600 MHz
- ☐ True rms response up to 30V*
- ☐ VSWR less than 1.2 to 600 MHz
- ☐ Linear dc output

* With appropriate accessory

GENERAL DESCRIPTION

The Model 91K offers exceptionally high input impedance and the very best combination of voltage sensitivity and frequency response. Of particular merit is its usefulness for direct in-circuit measurements where high input impedance is more important than the extreme voltage sensitivity and wide frequency range offered by our other Sensitive RF Voltmeters.

The rf probe input impedance is greater than 4 MΩ shunted by 2.5 pF at frequencies up to 25 MHz and greater than $(100/f_{MHz})$MΩ at frequencies above 25 MHz, shunted by 2.5 pF. This is at least ten times higher than conventional rf millivoltmeters.

Frequency coverage is 0.5 to 600 MHz with eight ranges of sensitivity from 10 mV fs to 30 V fs in a 1-3-10 sequence. Subcalibrations of 1 and 2 mV are added on the 10 mV fs range. A dBm (50 Ω) scale is also provided. The instrument gives true rms response for inputs up to 300 mV (to 30 V with accessory 100:1 voltage divider).

True to the 91 RF Voltmeter series standard of excellence, the 91K also provides highly reproducible voltage measurements over its entire frequency range, low noise, exceptional stability, and ruggedness of design.

Accessories provided as standard equipment include 91-22A, RF Probe; 91-8B, 50 ohm Adapter; and 91-13B, Probe Tip.

A dc output which is proportional to input voltage for on-scale readings is available at front-panel terminals. Jumper connections at a rear terminal board provide outputs suitable for either display on a digital voltmeter or for application to a recorder. For digital voltmeters the output may be adjusted for any full scale value from 0 to 100 mV or 300 mV, depending on the numerics of the rf voltage range. For recorders the full scale output level is adjustable to any value from 0 to 300 mV. Output resistance is 0 to 40 KΩ, depending on output level setting.

THEORY OF OPERATION

The Model 91K comprises an rf detector probe with built-in impedance multiplier, chopper type dc amplifier, and a voltmeter.

The rf probe rectifies the input voltage using a full wave diode rectifier providing true rms response for input levels up to 300 mV. As the input voltage increases beyond this level, response gradually approaches peak-to-peak (calibrated on the meter scale in rms).

The rectified output from the probe, after passing through an attenuator network (range selector), is converted to a 60 Hz signal by a low noise mechanical chopper. It is then fed to the narrow band feed-back stabilized amplifier. The 60 Hz output from the amplifier is rectified by a voltage doubler and passed through a diode network to convert the non-linear response of the rf probe to a linear current suitable for metering.

Great care has been taken in the design and construction of the Model 91K to hold noise, hum, and other sources of spurious deflection to a minimum. Jitter of the indicating needle on the most sensitive range (10 mV fs) is less than 2% fs, and sensibly zero on all other ranges. The probe cable of the Model 91K is of special low noise construction and even vigorous flexing causes no change in meter deflection.

APPLICATIONS

The unusually high input impedance and reasonably broad frequency range of the Model 91K suit the instrument for a great variety of rf measuring functions, especially those measurements where the loading influence of the instrument used is critical, such as proper alignment of rf filters and determining the frequency response of both active and passive networks. The Model 91K is also valuable for such applications as the measurement of high frequency characteristics of transistors and other semiconductor devices; measurement of VSWR and return loss in transmission lines and attenuator systems; determining the harmonic content of rf signals, and the measurement of broad band noise.

SPECIFICATIONS

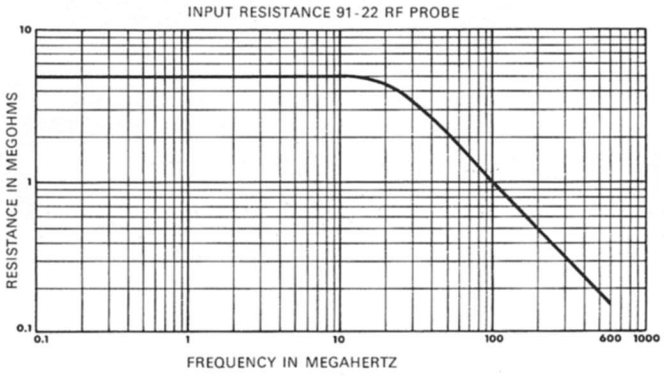
Full Scale Volts: 10 mV to 30 V; 8 ranges in a 1-3-10 sequence

Voltage Measuring Range: 1 mV to 30V (to 300 V with accessory 91-7C, 100:1 Voltage Divider)

Frequency Range: 500 KHz to 600 MHz

Accuracy: ±3% from 500 KHz to 100 MHz
±5% from 100 MHz to 400 MHz
±10% from 400 MHz to 600 MHz

Input Impedance: Greater than 4MΩ shunted by 2.5 pF up to 25 MHz and greater than $(100/f_{MHz})$ MΩ above 25 MHz (see curve)



Noise: Indicator unrest is less than 2% fs on most sensitive (10mV fs) range; sensibly zero on all other ranges

dBm Range: −40 to +40 dBm (50Ω)

Waveform Response: True rms for input levels up to 300 mV (or 30 V with accessory 91-7C, 100:1 Voltage Divider), gradually changing to peak-to-peak reading (calibrated in rms) above 300 mV

Crest Factor: 420 to 1.4, depending on input level

Power Sensitivity: 0.02 μW, max.

VSWR: Less than 1.2 up to 600 MHz with 91-8B, 50Ω Adapter or with 91-14A, Tee Adapter and 91-15A, 50Ω Termination

Linear DC Output: Proportional to rf input voltage for on-scale readings; "DVM" mode, fs values continuously adjustable from 0 to 100 mV or 300 mV, depending on range numerics; "REC" mode, fs value continuously adjustable from 0 to 300 mV for all ranges; Output resistance 0 to 40 KΩ, depending on output level setting.

Accessories Furnished:
Model 91-22A, RF Probe (with low noise cable and connector assembly)
Model 91-13B, Probe Tip
Model 91-8B, 50 ohm Adapter (BNC)

Accessories Available:

Model Number	Description
91-6C	Unterminated BNC Adapter
91-7C	100:1 Voltage Divider
91-14A	Tee Adapter (Type N, 50Ω)
91-15A	50 ohm Termination
91-16A	Unterminated N Adapter

Mechanical Specifications: 7¼" w × 10¼" d × 11 "h (excluding leather carrying handle); net weight, 12 lbs.; packed for shipment, 16 lbs.

Power Line Options:

91K	105 to 125 V, 58 to 62 Hz only (standard)
	105 to 125 V, 48 to 52 Hz only*
	210 to 250 V, 48 to 52 Hz only*
91K-S2	105 to 125 V, 48 to 400 Hz

*Specify this voltage and frequency if required. Model number does not change.

dB Scale Options:

91K-S1	Same as 91K but with dB scale (31.6 V = 0dB)
91K-S3	Same as 91K-S2 but with dB scale (31.6 V = 0dB)

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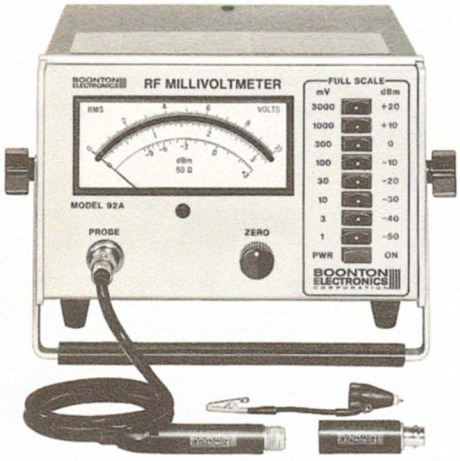
BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY

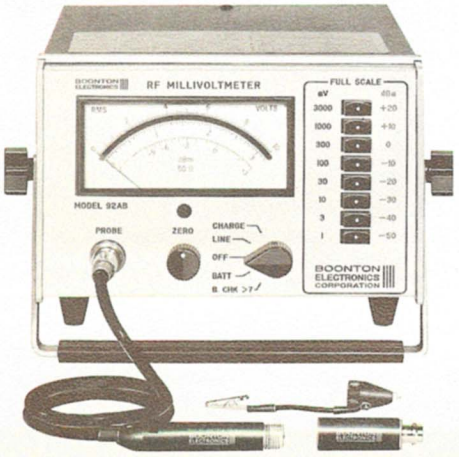
Model 92A Series RF Millivoltmeters

Programmable, Solid State, RF Millivoltmeters Analog, Digital-Readout, and Battery Versions



Analog Model 92A

Digital Model 92AD



Battery Model 92AB

STANDARD FEATURES

- ☐ Basic accuracy 1% rdg + 1% fs
- ☐ Measures 100 μV† to 3 V* from 10 kHz to 1.2 GHz
- ☐ Programmable ranges and functions
- ☐ True RMS response to 30 mV**
- ☐ Fast, high-level linear dc-output
- ☐ High input resistance, low input capacitance
- ☐ Half-rack packaging
- ☐ High overload tolerance
- ☐ BCD Data outputs and commands (Model 92AD)

OPTIONAL FEATURES

- ☐ Logic-level programming
- ☐ Many scale variations
- ☐ Autoranging (Model 92AD)
- ☐ Digital dBm readout (Model 92AD)

INTRODUCTION

The Models 92A, 92AB and 92AD have been designed as definitive rf millivoltmeters. Accuracy at all frequencies and voltage levels is the best ever offered by Boonton Electronics, long a leader in the rf millivoltmeter field.

No warm-up delay, high reliability, long intervals between calibrations, plug-in PC boards for ease of servicing, light weight, and little heat, are characteristics of the solid state design.

All these instruments are programmable rf millivoltmeters with linear dc output. They may be specified with a variety of options including those necessary for integration into a test console or interface with a fully computer-controlled test-system.

The rf probe is supplied with a probe tip and a terminated 50 Ω BNC adapter as standard equipment. A complete kit of probe accessories is also available including a storage case. Clips for holding out-of-use accessories are provided at the rear.

Important input and accuracy specifications are shown on a reference plate attached to the top of the instrument case and recalibration information is printed inside the top cover.

†200 μV on Model 92AD
*To 300 V, up to 700 MHz with accessory 100:1 divider
**To 3 V, up to 700 MHz with accessory 100:1 divider

VERSIONS

ANALOG READOUT VERSION (Model 92A)

The large mirrored-scale panel-meter has linear 0-3 and 0-10 voltage scales finely divided for precise readings. A dBm scale referred to I mW in 50 Ω is standard. Range push buttons are marked in mV and dBm to correspond with the meter scales.

RECHARGEABLE BATTERY VERSION (Model 92AB)

A long-life rechargeable Nicad battery pack and recharging circuits are included internally in the Model 92AB. Batteries are installed so that all options may be accommodated. A front-panel switch selects battery or line operation, battery check, and charge. Continuous operation for a full 16 hours and recharge in 14 hours are provided. Batteries are charged at half rate during line operation.

Primary applications are for field use or for measurements where complete isolation from the line is required.

In performance the 92AB is identical to the line-operated Model 92A.

DIGITAL READOUT VERSION (Model 92AD)

The digital version has a 3-digit readout plus "1" for 5% overrange. It employs nixie-type display tubes for bright, easy-to-read characters, and includes BCD outputs and commands. Normally a free-running system with a display period of 250 ms, the readout may be externally triggered to give faster BCD outputs if visual readings are not required.

An unusual feature allows the zero to be quickly and easily adjusted using the vertical edge-meter to the right of the display. The meter is calibrated in dBm, 50 Ω and is additionally useful for peaking and nulling.

STANDARD FEATURES

Programming

Input-range programming by external contact closure or PNP transistor to ground is standard on all models. When options add other functions these are also programmable.

Wide Frequency Range

The calibrated frequency-range of all versions extends from a low 10 kHz to 1.2 GHz with uncalibrated response to beyond 8 GHz. Relative accuracy above 1.2 GHz is typically ± 0.5 dB.

A Model 91-8B 50 Ω Terminated BNC Adapter is supplied as standard for 50 Ω voltage measurements up to 600 MHz. For measurements above this frequency and for thru-line voltage measurements, the optional accessory Model 91-14A Tee Adapter is recommended. It is designed to compensate for the rf probe capacitance and to present a good vswr (better than 1.15) up to 1.2 GHz. It may be used in conjunction with the Model 91-15A 50 Ω Load for terminated voltage measurements. In a coaxial line, its insertion loss is low; however, a chart is supplied showing loss vs. frequency.

Measurements from 100 Microvolts to 3 Volts

Eight ranges from 1 mV full scale to 3V full scale are arranged in 1-3-10 sequence. No attenuator attachments are required for measurements up to 3V. While this range is ample for the majority of rf voltage measurements, voltage capability can be increased to 300 V (up to 700 MHz) by using the accessory Model 91-7C 100:1 Voltage Divider. Use of the 100:1 voltage divider also increases the input resistance of the probe by a factor of greater than 100.

True RMS Response

All models provide true rms response for signal inputs below approximately 30 mV (below 3 V, and up to 700 MHz, with the Model 91-7C 100:1 Voltage Divider). As the input level increases, waveform response gradually approaches peak-to-peak, calibrated on the meter scale in rms. Thus, in addition to making precise, sinusoidal voltage measurements at all levels, they measure non-sinusoidal signals within the rms region without loss of accuracy.

The full wave rf probe detector circuit eliminates asymmetry as a source of error at all levels.

Low Noise

Extensive care is taken throughout the design and construction to hold noise from all sources to a minimum. (See Specifications.)

The probe cable is of special low noise design, and vigorous flexing causes momentary, minor deflections only on the most sensitive range. The rf probe is not sensitive to shock or vibration; even sharp tapping on the probe barrel causes no visible deflection on any range. Amplification takes place at 94 Hz, reducing susceptibility to any 50 or 60 Hz line-frequency-related fields.

Chopper Circuit

A unique sampling circuit reduces even further the already low noise contributed by the mechanical chopper, greatly reducing the effects of change in chopper performance that could occur with the passage of time.

Minimal Zero Adjustment

Zero adjustment is not required on the upper five sensitivity ranges. For measurements on the lower three ranges the ZERO control is set on the most sensitive range prior to operation. This control balances out small thermal voltages in the probe elements and, once adjusted, requires only infrequent checking during the course of subsequent measurements.

DC Output

The dc output as well as having relatively high current capability (1 mA into 1000 Ω), is also linear and stable. It is ideal for use with external recorders, plotters or DVMs.

OPTIONAL FEATURES

Logic-Level Programming: Logic-level programming accepts standard positive TTL inputs with individual lines controlling ranges and any option-added functions. This plug-in option is available on all models.

Autoranging: When autoranging is specified (Model 92AD only), the digits, decimal point, and units are quickly and automatically displayed creating the ultimate in no-involvement rf voltage measurement. Up-ranging occurs at 3 percent above full scale and down-ranging at 31 percent of full scale.

Autoranging may be selected remotely or at the front panel.

dBm Display: A logarithmic operating mode allows digital indication of voltage in terms of dBm. The complete number of dBm from +20 to —60 is digitized making it unnecessary to refer to the range switch position when taking a reading. 50 Ω or 75 Ω referenced versions are available.

Special Meter Scales: As options, meters may be ordered with the dB scales referred to 1 mW in 75 Ω, 1 V, or 1 mV. All dB scales may be specified as being uppermost if so desired.

SPECIFICATIONS

ANALOG READOUT VERSION (Model 92A)

Voltage Range: 100 μV to 3 V (300 V up to 700 MHz with accessory 100:1 Voltage Divider)

Full Scale Voltage Ranges: 1, 3, 10, 30, 100, 300, 1000 and 3000 mV.

DBM Range: —60 to +23 dBm (+63 dBm up to 700 MHz with Model 91-7C 100:1 Voltage Divider)

Frequency Range: 10 kHz to 1.2 GHz (uncalibrated response to approximately 8 GHz).

Accuracy:

	1% fs, plus			
300 mV to 3 V	1% rdg	1% rdg	3% rdg	10% rdg
100 μV to 300 mV*	2% rdg			7% rdg
	10 kHz	50 kHz	150 MHz	700 MHz 1.2 GHz

*Below 1 mV add 1% fs; below 200 μV use correction curve supplied.

Waveform Response: True rms response for input levels up to 30 mV (3 V to 700 MHz with Model 91-7C 100:1 Voltage Divider), with transition to peak-to-peak (calibrated in rms) at higher levels.

Crest Factor:

Voltage Range	0.001	0.003	0.01	0.03	0.1†	0.3†	1†	3†
Crest Factor	420 to 42	42 to 14	14 to 4.2	4.2 to 1.4	420 to 42	42 to 14	14 to 4.2	4.2 to 1.4

†With Model 91-7C 100:1 Voltage Divider

Input Impedance: See Figures 1. and 2. (at right)

VSWR: Less than 1.15 to 1.2 GHz (Return Loss greater than 23 dB) See Figures 3. and 4. (at right)

Power Sensitivity: 200 pW, minimum detectable power in 50 Ω.

RFI: There is no detectable radiated or conducted leakage from instrument or probe.

Meter: 4½ inch taut band, response time <1s for fs
Two linear voltage scales
0 to 3; 0.05 per division
0 to 10; 0.1 per division
One logarithmic dBm scale
−10 to +3; 0.2 per division max.

Indicator Unrest:	*Indicated Voltage*	*Unrest*
(1 mV fs range only)	Above 600 μV	<1% fs
	300 μV to 600 μV	<2% fs
	100 μV to 300 μV	<5% fs

Temperature: In accordance with ANSI (ASA) Spec. 39.7

Temperature Range	Temperature Influence *	
	Instrument	RF Probe
Ref. 21°C to 25°C	0	0
Normal, 18°C to 30°C	0	±1% rdg
Severe, 10° C to 40°C	±1% rdg	±4% rdg

*Add to accuracy specification

Programming: External closure or PNP transistor to ground selects each range. Source: −12 V behind 15 kΩ. Speed: 100 ms per range change. (Logic-level programming optional)

DC Output: 0 to 10 V proportional to rf input voltage Source resistance 9 kΩ. Will deliver 1 mA to 1 kΩ load (1 V); Tracking accuracy as previously specified for meter indication.

Response Time: Full scale input step function response time; less than 100 ms at dc output on 30 mV fs to 3 V fs ranges increasing to 1 s. on the 1 mV fs range.

Power: 115 or 230 V ±10%, 50 to 400 Hz, 8 W.

Dimensions: 5.2″ H (without feet), 8.3″ W (½ module) 11.7″ D (132 x 211 x 293 mm)

Weight: Net 7.5 lbs (3.4 kg) (with standard accessories) Shipping, 10 lbs (4.6 kg)

Accessories Furnished: Model 91-12F RF Probe
Model 91-13B Probe Tip
Model 91-8B 50 Ω BNC Adapter

RECHARGEABLE BATTERY VERSION (Model 92AB)

Battery Use/Charge Time: 16 h use for 14 h charge (charges at half rate during line operation).

Battery Type: Two 18 V Nicad

Weight: Net, 10.5 lbs (4.8 kg) (with standard accessories) Shipping, 13 lbs (5.9 kg).

All other specifications and options are the same as for Model 92A

DIGITAL READOUT VERSION (Model 92AD)

Voltage Range: 200 μV to 3 V (300 V up to 700 MHz with accessory 100:1 Voltage Divider)

Voltage Accuracy:

	1% fs, plus			
300 mV to 3 V	1% rdg	1% rdg	3% rdg	10% rdg
200 μV to 300 mV*	2% rdg			7% rdg
	10 kHz	50 kHz	150 MHz	700 MHz 1.2 GHz

*Below 1 mV add 1% fs

INPUT CHARACTERISTICS

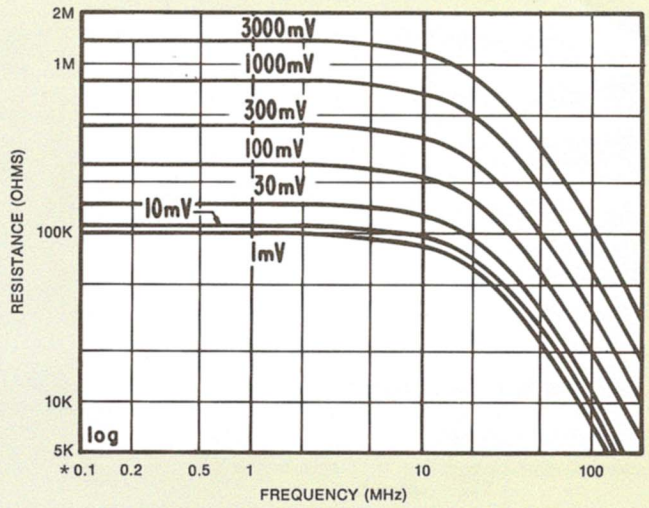


Figure 1. Input resistance vs. frequency of RF Probes for various input-levels

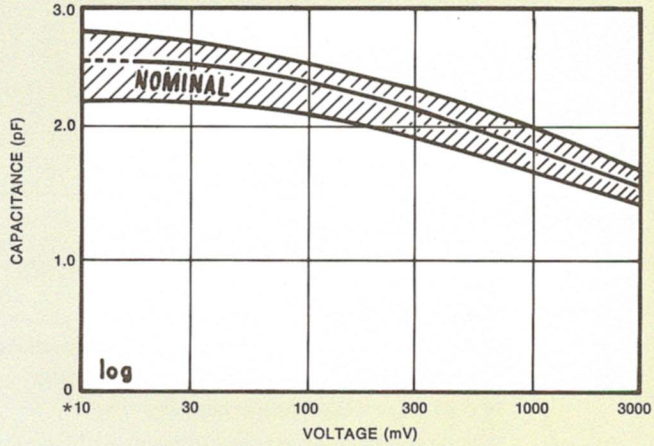


Figure 2. Input capacitance vs. input level of Model 91-12F RF Probe

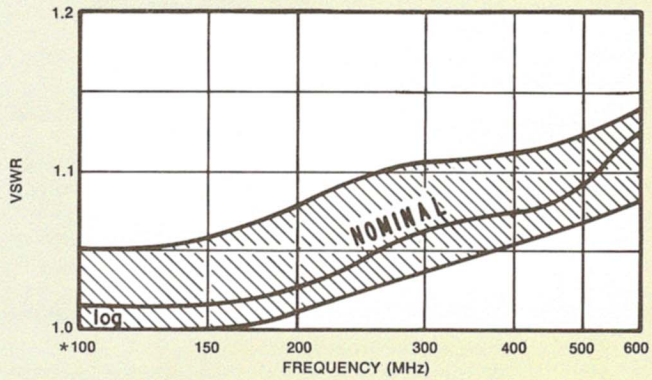


Figure 3. VSWR of RF Probe with Model 91-8B 50 ohm Adapter

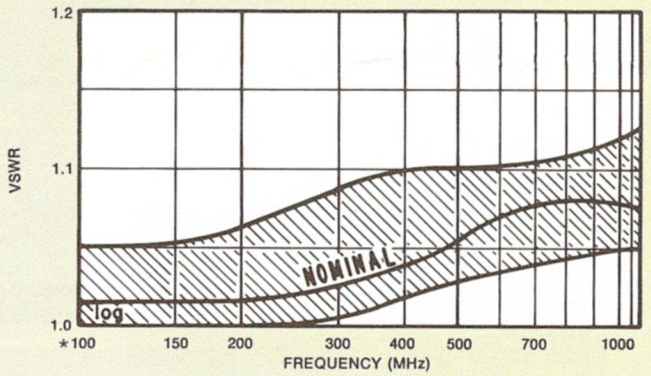


Figure 4. VSWR of RF Probe with Model 91-14A Tee Connector and Model 91-15A 50 ohm Termination

*Graphs extend down to lowest specified frequency or voltage without change.

dBm Accuracy:
(Option -09)

+23 to —10 dBm	0.3 dB	0.3 dB	0.4 dB	1.0 dB
—10 to —60 dBm*	0.4 dB			0.8 dB
	10 kHz	50 kHz	150 MHz	700 MHz 1.2 GHz

*Below —50 dBm add 0.2 dB.

Display: Nixie-type, non-blinking, 3 digits + 1 for 5% overrange. Blanked for overrange and below 20% fs. Vertically-mounted edge-meter to right of display is calibrated dBm, 50 Ω. Accuracy not specified.

Display Period: 250 ms

Encode Period: 10 ms

Data Outputs: 1-2-4-8 binary coded decimal information.
1-2-4 binary coded range information.
Overrange, underrange, encode complete

Commands: Encode hold, encode trigger, manual disable, auto enable (-01 option) and dBm enable (-09 option).

Logic Levels: Logic 1 ≥ 3 V; logic 0 ≤ 0.3 V
TTL compatible.

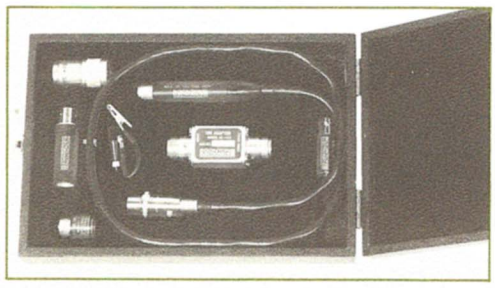
Power: 115 or 230 V 10%, 50 to 400 Hz, 10 W

Weight: Net 9 lbs (4.1 kg) (with standard accessories)
Shipping 11.5 lbs. (5.2 kg)

All other specifications are the same as Model 92A.
Options as specified

OPTIONS

MODEL SUFFIX	DESCRIPTION
Models 92A and 92AB	
-02	Logic-level programming option; 8 line logic-level input selects range. TTL compatible.
-03	dBV option; dB scale is referred to 1 V.
-04	dBV option; dB scale, referred to 1 V is uppermost
-05	75 Ω, dBm option; dBm scale is referred to 75 Ω ; 75 Ω 91-8B/1 BNC adapter supplied
-06	75 Ω, dBm option; dBm scale, referred to 75 Ω is uppermost ; 75 Ω 91-8B/1 BNC adapter supplied
-07	50 Ω, dBm option; dBm scale referred to 50 Ω is uppermost
-08	Rear signal-input option.
-12	dBmV option; dBmV scale is uppermost
MODEL 92AD	
-01	Autoranging option; digits, decimal points, and units are automatically displayed. Allows programmable and manual selection of autorange.
-02	Logic-level programming option. Logic-level inputs select input ranges, mV, dBm, and autorange functions as optioned. TTL compatible.
-08	Rear signal-input option.
-09	50 Ω dBm display option ; allows programmable and manual selection of either dBm or mV to be read on the digital display. Logic-level outputs indicate mV and ± dBm. dBm is within 0.2 dB.
-10	75 Ω dBm display option. Function as Option -09; 75 Ω 91-8B/1 BNC adapter supplied



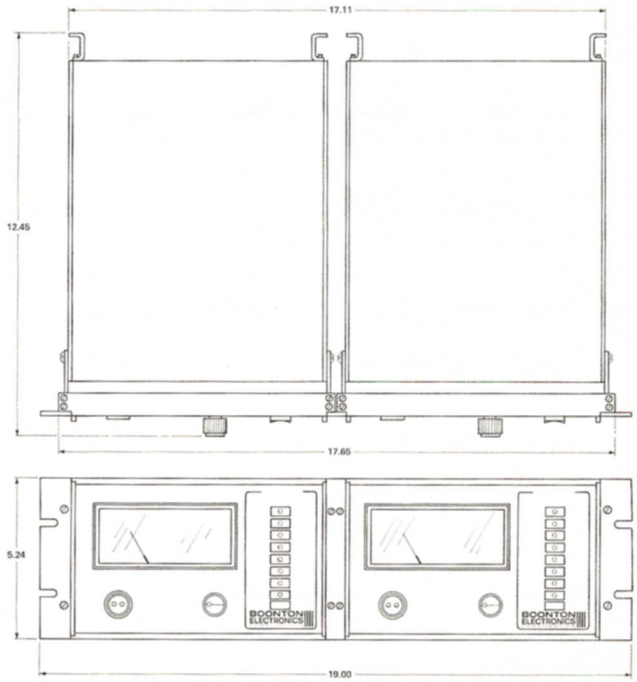
Accessories in storage case

ACCESSORIES AVAILABLE

Description	Model
Low Frequency Probe for measurements from 250 MHz down to 1 kHz; input resistance essentially the same as that of Model 91-12F	91-4C
Unterminated BNC Adapter for coaxial connection up to approximately 100 MHz or to 400 MHz when fed from a 50 Ω source in an electrically short system.	91-6C
100:1 Voltage Divider; attenuates input signal by a factor of 100 (±1%), permitting measurements up to 300 V, and extending the rms measuring range to 3 V; increases input resistance by a factor of >100; operates from 50 kHz to 700 MHz. Maximum input potential, 1000 V, dc plus peak ac.	91-7C
50 Ω BNC Adapter for measurements up to 600 MHz in a 50 Ω system; for vswr see curve of Figure 3.	91-8B
RF Probe with low noise cable and connector assembly for measurements from 10 kHz to 1.2 GHz; see Figures 1 and 2 for input resistance and capacitance.	91-12F
Removable Probe Tip with grounding clip lead; for use up to approximately 100 MHz.	91-13B
Type N Tee Connector; with Model 91-15A Termination (see below) permits connection into 50 Ω line; required for measurements above approximately 100 MHz; for vswr see curve of Figure 4.	91-14A*
Type N 50 Ω termination for use with Model 91-14A Tee Connector.	91-15A*
Unterminated Type N Adapter	91-16A
Storage container for accessories	91-18A
Accessory Kit Model 91-6C Unterminated BNC Adapter Model 91-7C 100:1 Voltage Divider Model 91-14A 50 Ω Tee Adapter Model 91-15A 50 Ω Termination Model 91-18A Storage Case with room for furnished accessories	91-24A
Rack-mounting kit (mounts left or right)	92-1A
Dual rack-mounting kit	92-1B

*Available in 75 Ω versions (reduced frequency range).

RACK MOUNTING KITS



Model 92-1B Dual Rack Mounting Kit is illustrated. Model 92-1A Kit is similar except that a blank half-rack panel is supplied instead of one of the two mounting frames.

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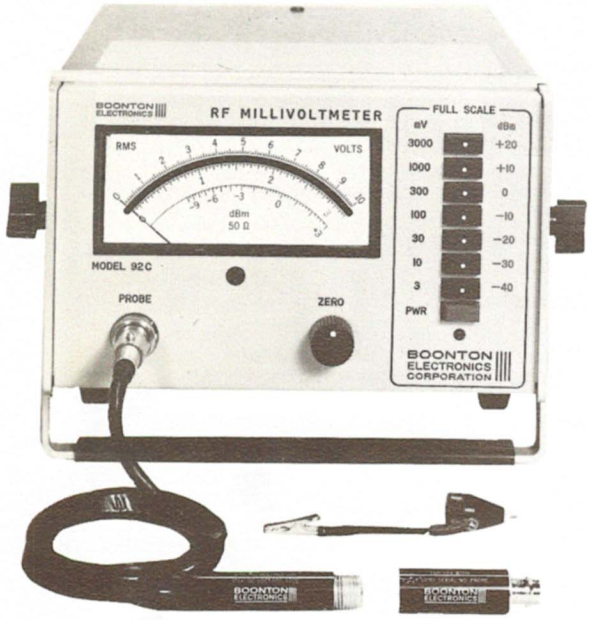
BOONTON ELECTRONICS CORPORATION
PARSIPPANY, NEW JERSEY U.S.A.

Model 92C RF Millivoltmeter

Economical RF Millivoltmeter With All-Solid-State Design



STANDARD FEATURES

- ☐ Measures from 500 μV to 3 V.*
- ☐ Frequency range 10 kHz to 1.2 GHz.
- ☐ Basic accuracy 2% fs ± 1% rdg.
- ☐ True rms up to 30 mV.**
- ☐ High input resistance, low input capacitance.
- ☐ High overload tolerance.
- ☐ Compact, half-rack packaging.

OPTIONAL FEATURES

- ☐ Many scale variations.
- ☐ Rear signal input.

* To 300 V with accessory 100:1 divider.

** To 3 V with accessory 100:1 divider.

INTRODUCTION

The Model 92C has been designed as a basic rf millivoltmeter, delivering substantially the same quality performance as its big brothers, the 92A and the 92AD, but at a lower price. Economy has been achieved, not by lowering quality, but by eliminating some of the specialized features of the more expensive instruments (programmability, analog or BCD output, the seldom-needed lowest range) and by working to a more modest accuracy specification. The result is a rugged, reliable instrument that will deliver superb performance.

High reliability has been attained in the Model 92C by making the entire instrument of solid-state design, including the chopper. No warm-up delay, long intervals between calibrations, light weight, and low heat are other characteristics of this design.

Standard equipment furnished with the Model 92C includes the rf probe, with probe tip and a terminated 50 Ω BNC adapter. A complete kit of probe accessories is available, including a fitted storage case. Clips are provided on the rear of the cabinet for holding out-of-use accessories.

The Model 92C was carefully designed and constructed to hold noise from all sources to a minimum. The probe cable is a special low-noise type, and the probe itself is insensitive to shock or vibration effects. Amplification is at 94 Hz, reducing susceptibility to line-frequency-related fields.

The zero adjustment need be made only on the lowest voltage range; it will then hold on all ranges for extended periods of operation.

SPECIFICATIONS

Voltage Range: 500 μV to 3 V (300 V up to 700 MHz with accessory Model 91-7C 100:1 Voltage Divider)

Full Scale Voltage Ranges: 3, 10, 30, 100, 300, 1000, and 3000 mV.

dBm Range: —50 to +23 dBm (+63 dBm up to 700 MHz with Model 91-7C 100:1 Voltage Divider)

Frequency Range: 10 kHz to 1.2 GHz (uncalibrated response to approximately 8 GHz).

Accuracy:

	2% fs, plus			
300 mV to 3 V	1% rdg	1% rdg	3% rdg	10% rdg
500 μV to 300 mV	2% rdg			7% rdg
	10 kHz	50 kHz	150 MHz	700 MHz 1.2 GHz

Waveform Response: True rms response for input levels up to 30 mV (3 V to 700 MHz with Model 91-7C 100:1 Voltage Divider), with transition to peak-to-peak (calibrated in rms) at higher levels.

Crest Factor:

Full Scale (mV)	3	10	30	300†	1000†	3000†
Crest Factor	84 to 14	21 to 4.2	8.4 to 1.4	84 to 14	21 to 4.2	8.4 to 1.4

†With Model 91-7C 100:1 Voltage Divider

Input Impedance: See Figures 1. and 2. (at right)

VSWR: Less than 1.15 to 1.2 GHz (Return Loss greater than 23 dB) using appropriate input accessories

RFI: There is no detectable radiated or conducted leakage from instrument or probe.

Meter: 4½ inch taut band, response time <1s for fs
Two linear voltage scales
0 to 3; 0.05 per division
0 to 10; 0.1 per division
One logarithmic dBm scale
−10 to +3; 0.2 per division max.

Power: 115 or 230 V ±10%, 50 to 400 Hz, 4 W.

Dimensions: 5.2″ H (without feet), 8.3″ W. (½ module)
11.7″ D (132 x 211 x 293 mm)

Weight: Net 7.5 lbs (3.4 kg) (with standard accessories)
Shipping, 10 lbs (4.6 kg)

Accessories Furnished: Model 91-12F RF Probe
Model 91-13B Probe Tip
Model 91-8B 50 Ω BNC Adapter

Temperature: In accordance with ANSI (ASA) Spec. 39.7

Temperature Range	Temperature Influence *	
	Instrument	RF Probe
Ref. 21°C to 25°C	0	0
Normal, 18°C to 30°C	0	±1% rdg
Severe, 10° C to 40°C	±1% rdg	±4% rdg

*Add to accuracy specification

OPTIONS

MODEL SUFFIX	DESCRIPTION
-03	dBV option; dB scale is referred to 1 V.
-04	dBV option; dB scale, referred to 1 V is uppermost
-05	75Ω, dBm option; dBm scale is referred to 75Ω ; 75 Ω 91-8B/1 BNC adapter supplied
-06	75Ω, dBm option; dBm scale, referred to 75Ω is uppermost ; 75 Ω 91-8B/1 BNC adapter supplied
-07	50Ω, dBm option; dBm scale referred to 50Ω is uppermost
-08	Rear signal-input option.
-12	dBmV option; dBmV scale is uppermost

ACCESSORIES AVAILABLE

Description	Model
Low Frequency Probe for measurements from 250 MHz down to 1 kHz; input resistance essentially the same as that of Model 91-12F	91-4C
Unterminated BNC Adapter for coaxial connection up to approximately 100 MHz or to 400 MHz when fed from a 50 Ω source in an electrically short system.	91-6C
100:1 Voltage Divider; attenuates input signal by a factor of 100 (±1%), permitting measurements up to 300 V, and extending the rms measuring range to 3 V; increases input resistance by a factor of >100; operates from 50 kHz to 700 MHz. Maximum input potential, 1000 V, dc plus peak ac.	91-7C
50 Ω BNC Adapter for measurements up to 600 MHz in a 50 Ω system.	91-8B *
RF Probe with low noise cable and connector assembly for measurements from 10 kHz to 1.2 GHz; see Figures 1 and 2 for input resistance and capacitance.	91-12F
Removable Probe Tip with grounding clip lead; for use up to approximately 100 MHz.	91-13B
Type N Tee Connector; with Model 91-15A Termination (see below) permits connection into 50 Ω line; required for measurements above approximately 100 MHz.	91-14A*
Type N 50 Ω termination for use with Model 91-14A Tee Connector.	91-15A*
Unterminated Type N Adapter	91-16A
Storage container for accessories	91-18A
Accessory Kit Model 91-6C Unterminated BNC Adapter Model 91-7C 100:1 Voltage Divider Model 91-14A 50 Ω Tee Adapter Model 91-15A 50 Ω Termination Model 91-18A Storage Case with room for furnished accessories	91-24A
Rack-mounting kit (mounts left or right)	92-1A
Dual rack-mounting kit	92-1B

*Available in 75 Ω versions (reduced frequency range).

INPUT CHARACTERISTICS

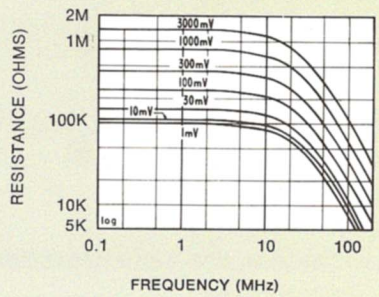


Figure 1. Input resistance vs. frequency of RF Probes for various input-levels

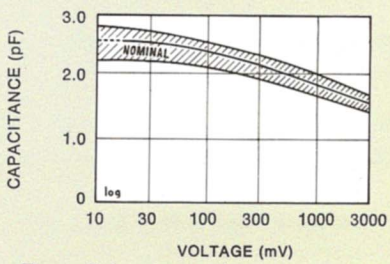


Figure 2. Input capacitance vs. input level of RF Probes

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BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY U.S.A.

Model 93AD
True RMS Voltmeter

Programmable Digital True RMS Voltmeter With BCD Output

STANDARD FEATURES

- ☐ Measures from 300 μV to 300 V.
- ☐ 3½-digit LED display.
- ☐ Auxiliary edge-meter for easy peaking or nulling.
- ☐ BCD and analog outputs.
- ☐ Fully programmable.
- ☐ Selectable bandwidth and response time.
- ☐ Basic accuracy of 1% rdg ± 1 digit.
- ☐ 10 Hz to 20 MHz frequency range.

OPTIONAL FEATURES

- ☐ Digital dBm readout (600 Ω).
- ☐ Automatic ranging.
- ☐ Rear signal input.
- ☐ High-impedance probe.
- ☐ Rack mounting.

The Boonton Model 93AD is designed to supply true rms voltage measurement capability in a digital, fully-programmable instrument at a moderate price, with no compromise in quality. Maximum utility is assured by such standard features as BCD and analog outputs, full remote control, and auxiliary analog panel meter.

The Model 93AD is of completely solid-state design, including the chopper. This contributes materially to the reliability, low maintenance cost, light weight and compact physical size of the instrument. Amplification at 94 Hz reduces susceptibility to line-frequency-related fields in this low-noise design.

The 3½ digit LED digital display avoids ambiguous readings; the small auxiliary meter, calibrated in dBm (600 Ω), is useful for peaking or nulling adjustments — confusingly difficult using only a digital display.

The voltage range is divided into 12 segments from 1 mV to 300 V full-scale, arranged in a 1, 3, 10 sequence. (— 50 to + 60 dBm with dBm option). Basic accuracy over most of the 10 Hz to 20 MHz frequency span is 1% rdg ± 1 digit. Bandwidth (100 kHz or 20 MHz) and response time may be selected by panel switch, or remotely, to suit measurement requirements.

The BCD output (8,4,2,1) employs standard positive logic, TTL compatible. The analog output is +10 VDC for full-scale reading on each range. Input impedance of the 93AD is 2 MΩ in parallel with 25 pF or less. (A high-impedance probe is available.)

Packaged in a 5¼″ high half-rack cabinet, the 93AD may be rack-mounted using the optional rack-mounting kit for one or two units.

SPECIFICATIONS

Voltage Range: 1 mV to 300 V fs, in 12 switched ranges.
(300μV lowest calibrated level)
— 60 to + 50 dBm fs with dBm option.
(1 mW 600 Ω ref.)

Selectable Frequency Range: 10 Hz to 20 MHz or 10 Hz to 100 kHz

Accuracy:

All voltage ranges

1 count, plus				
5% rdg	1.5% rdg	1% rdg	1.5% rdg*	5% rdg*

10 Hz 20 Hz 50 Hz 1 MHz 10 MHz 20 MHz

All dBm ranges (optional)

1 count, plus				
0.5 dB	0.2 dB	0.1 dB	0.2 dB*	0.5 dB*

10 Hz 20 Hz 50 Hz 1 MHz 10 MHz 20 MHz

* > 3 V unspecified

Stability: Useable after 2-minute warmup; < 0.3% long term drift after 1 hour.
± 10% line voltage: < 0.2% reading;
± 3% line frequency: < 0.2% reading .

Display: LED digital display, 3 digits + 1.
Decimal point, units (V, mV, dB), under-and over-range, polarity (dBm only) also indicated.
Analog edgemeter, calibrated over 12 dBm range.

Response: RMS, calibrated in rms, for sine, complex, pulse, or random waveforms.

Response Time: Fast: > 200 Hz, 1 second.
Slow: < 200 Hz, 4 seconds.

Crest Factor: 6 at full scale;
18 at down scale.

Input: Impedance: 2 MΩ, < 25 pF.
Equivalent noise: < 30 μV.
Swinging: (60 Hz, 120 Hz, 180 Hz) < 0.5% fs; < 1.0% ds.

Outputs: BCD 8, 4, 2, 1 for display (serial), range and mode information;
Logic Levels: Logic 1 = + 2.4 V to + 5.5 V.
Logic 0 = < ± 0.7 V.
Analog: + 10 V for full scale on "1" series ranges;
+ 9.5 V for full-scale on "3" series ranges.
Accuracy ± 5% rdg., ± 0.3% fs.
Source resistance 5 Ω approx.; maximum loading 1 mA at fs.

Remote Control: All functions and ranges commanded with logic zero referred to ground.

Power Requirements: 115 or 230 volts ± 10%, 50 to 400 Hz.

Dimensions: 5.2″ H x 8.3″ W x 12.5″ deep (132 x 211 x 318 mm)

Weight: 9.75 lbs. net (4.36 kg)

Options:

-01	Autoranging. Selects correct range for the voltage applied.
-08	Rear signal-input option.
-10	75 Ω dBm display.
-15	600 Ω dBm display.

Accessories:

93-1A	High-impedance probe. Input impedance 10 MΩ, < 11.5 pF; attenuation 10x.
92-1A	Rack-mounting kit, single.
92-1B	Rack-mounting kit, dual.

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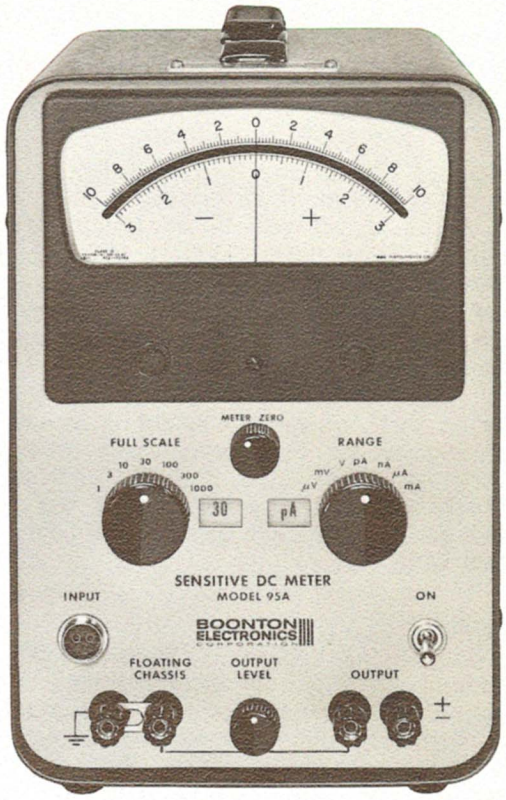
BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY

Model 95A Sensitive DC Meter

A Versatile, Reliable DC Microvolt/Picoammeter Of Exceptionally Wide Range

- Voltage range:
  10 μV end scale to 1000 V
  in 17 ranges
- Voltage sensitivity:
  1 μV
- Current range:
  1 pA end scale to 1 A in 25 ranges
- Current sensitivity:
  0.1 pA
- Noise less than 1 μV
- Drift less than 2 μV in 24 hours
  (non-cumulative)



- Response time less than 1 second
  on all ranges
- Floating or grounded input
- Constant 10 MΩ input resistance
  on all voltage ranges
- Highly stable dc output

General Description

The Model 95A is a sensitive, highly stable dc meter which accurately measures both voltage and current over exceptionally wide ranges. In addition it offers a dc output for driving a recorder or other external equipment. This output also permits use of the Model 95A as a high gain, general purpose low noise dc amplifier with a bandwidth of 1 Hz.

The instrument is packaged as a compact bench unit, and is supplied with a pair of 4-foot test leads terminated in insulated clips formed from beryllium copper for optimum thermal characteristics.

A rack mounting version, the Model 95AR, is also available, and is described on page 3 of this bulletin.

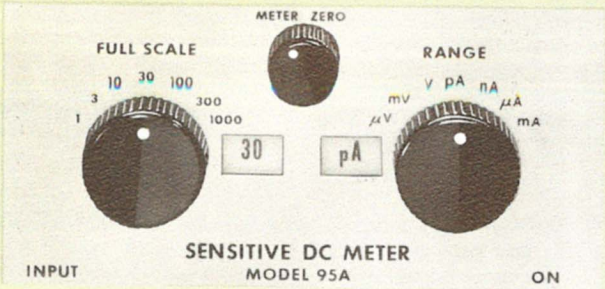


Figure 1. Detail view of front panel showing range switching system. Any of 42 voltage and current measuring ranges can be quickly and conveniently selected, with the units of measurements and end scale value displayed in the illuminated windows.

Forty-Two Voltage and Current Ranges

The voltage range of 10 microvolts (end scale) to 1000 volts is covered in seventeen sensitivity ranges. Voltage measurements may be reliably made down to 1 microvolt.

Twenty-five current ranges provide measurements from 1 picoampere (end scale) to 1 ampere; current sensitivity is 0.1 picoampere.

The unique switching system of the Model 95A permits swift, convenient selection of any of the forty-two ranges by manipulation of only two clearly marked controls. Both the units of measurement and the full scale value of the selected range are automatically displayed in large, illuminated windows.

Low Drift, Low Noise

An outstanding feature of the Model 95A is its excellent stability. No direct-coupled amplifier stages are employed in the instrument, thus avoiding drift and other instabilities commonly associated with dc amplifiers. After a half-hour warm-up, drift over a 24-hour period on the most sensitive voltage or current range (10 μv es or 1 pA es) is less than $\pm$2 microvolts or $\pm$0.2 picoampere, respectively, and is non-cumulative. On all other ranges drift is negligible.

Extensive filtering which provides more than 60 dB attenuation at power-line frequency, narrow-band amplification, careful shielding, and meticulous selection of materials to minimize thermal voltages all contribute to the low noise and hum level of the Model 95A. On the most sensitive voltage or current range, pointer unrest is less than $\pm$1 microvolt or $\pm$0.1 picoampere. On all other ranges indicator jitter is effectively zero.

Constant High Input Resistance

Input resistance is 10 megohms on ALL voltage ranges. By presenting a constant input resistance, the Model 95A can be switched from range to range without errors resulting from variations in source loading.

Grounded or Floating Voltage Measurements

As a voltmeter, the Model 95A can be operated either grounded or floating. For current measurements the "RANGE" selector automatically opens the ground connection for floating operation. This eliminates the possibility of inadvertently grounding a high source potential through one of the input voltage dropping resistors, which could cause substantial internal damage.

In the floating condition the input circuit has an insulation resistance of more than 500 megohms to the instrument case, which can be grounded through the power line for the safety of the operator.

Rapid Response; Short Recovery Time

Response time of the Model 95A (from 0 to 90% of end scale) is less than 1 second, even on the most sensitive voltage or current range. Recovery from overload does not exceed 1 minute on any range.

The rapid reaction of the Model 95A is convenient in the laboratory, but is especially valuable in production applications where it greatly facilitates repetitive test operations.

Stable DC Output

A separate dc amplifier output is available at front panel binding posts. Voltage output for end scale is continuously adjustable by means of the front-panel "OUTPUT LEVEL" control from 0 to $\pm$1 volt into a 1000 ohm load. Polarity is the same as the input. Output resistance remains constant at 2000 Ω, regardless of the range or the setting of the "OUTPUT LEVEL" control.

The dc output circuits involve no dc amplification and thus do not contribute drift or instability. Therefore, the drift of the dc output on the lowest voltage or current range is less than $\pm$2 microvolts or $\pm$0.2 picoamperes in 24 hours, and is non-cumulative. On all other ranges, drift is essentially zero.

Total modulation products (noise, hum, etc.) on the dc output (with input shorted) are less than $\pm$1 microvolt or $\pm$0.1 picoampere, referred to the input, on the lowest voltage and current range respectively, decreasing proportionally as amplifier gain is reduced. On the 100 μV es and 10 pA es ranges or above, noise is negligible.

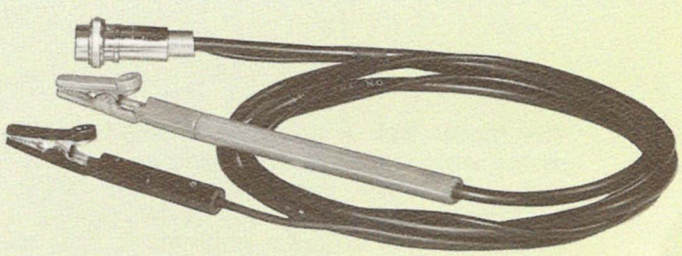


Figure 2. A pair of 4-foot test leads, terminated in insulated beryllium copper clips, is supplied with the Models 95A and 95AR.

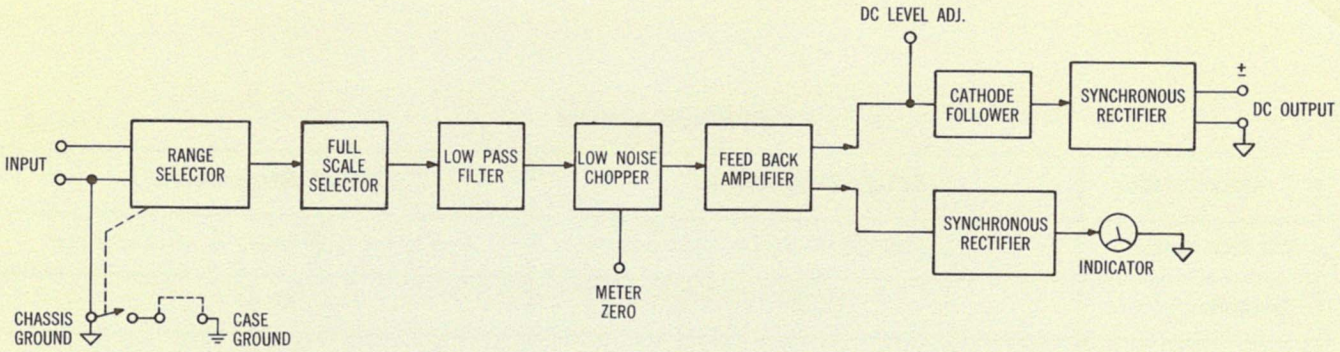


Figure 3. Block diagram of the Models 95A and 95AR

The dc output channel is independent of the metering circuit. Thus the output may be used simultaneously with the meter with no interaction. Similarly, adjustment of the dc output level has no influence on the meter reading. Maximum dc input/output voltage gain is 100,000.

Theory of Operation

The dc input first passes through the range selecting network. On the more sensitive voltage and current ranges, the selector adjusts the gain of the amplifier by setting the degree of negative feedback. On the higher voltage ranges, dividing networks attenuate the input level as required. When set to any of the current positions, the selector inserts an appropriate precision dropping resistor to develop a voltage suitable for measuring in terms of current.

The output from the range selector is passed through a low pass filter which provides approximately 3 dB attenuation at 1 Hz and more than 60 dB attenuation at 60 Hz. The filtered test voltage is converted to ac at power line frequency by a low noise, drift free mechanical chopper.

The resultant ac signal is applied to a high gain, feedback stabilized, narrow band, ac amplifier. The coupling networks and associated filters in the amplifier are designed for 50 to 60 Hz operation, with pronounced roll-off outside of these limits to reduce the noise level further.

The dc level and polarity in the output circuit are restored by a synchronous rectifier. Thus, both amplitude and polarity of the input are indicated on the 6-inch zero-center mirrored scale meter.

A portion of the output from the ac amplifier is applied to a current stabilized isolating cathode follower and then to a synchronous rectifier which is independent of that for the metering voltage. The rectifier is so phased that the dc output has the same polarity as the input to the Model 95A. A filter network provides final smoothing of the dc output.

Model 95AR

The Model 95AR provides all of the measuring facilities of the Model 95A but is mechanically rearranged for mounting in a standard 19-inch rack. A duplicate input connection is provided at the rear of the instrument so that input may be made either at the front panel or behind the rack.

The Model 95AR measures 5¼″ x 19″ (panel size) x 8¾″ (behind panel). Weight is 18 lbs.

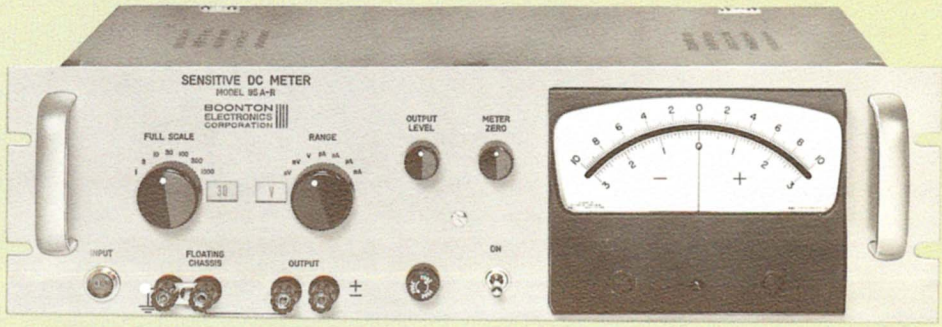


Figure 4. The Model 95AR, rack mounting version, provides measuring facilities identical to those of the Model 95A. Duplicate input connectors are provided at the rear of the Model 95AR so that input may be made either at the front panel or behind the rack.

SPECIFICATIONS

Characteristic	Voltage Measurements	Current Measurements
End Scale Ranges	10 μV to 1000 V in 17 ranges in 1-3-10 sequence	1 pA to 1 A in 25 ranges in 1-3-10 sequence
Sensitivity	1 μV	0.1 pA
Accuracy (including noise and drift)	$\pm$ 3% end scale	$\pm$ 4% end scale
Zero Stability	Zero drift on 10 μV range is less than $\pm$2 μV in 24 hours after 1/2-hour warm up and sensibly zero on all other ranges. Drift is non-cumulative.	Zero drift on 1 pA range is less than $\pm$0.2 pA in 24 hours after 1/2-hour warm up and sensibly zero on all other ranges. Drift is non cumulative.
Input Resistance	10 megohms on all ranges	See table below
Noise (input shorted)	Indicator unrest less than $\pm$1 μV on 10 μV range; sensibly zero on all other ranges.	Indicator unrest less than $\pm$ 0.1 pA on 1 pA range; sensibly zero on all other ranges.
Operating Modes	Grounded or floating	Floating only

Range	Input Resist.	Range	Input Resist.
1 pA to 100 pA	10 MΩ	300 nA	3.33 kΩ
300 pA	3.33 MΩ	1 μA	1 kΩ
1 nA	1 MΩ	3 μA	333 Ω
3 nA	0.333 MΩ	10 μA	100 Ω
10 nA	100 kΩ	30 μA	33.3 Ω
30 nA	33.3 kΩ	100 μA	10 Ω
100 nA	10 kΩ	300 μA	3.33 Ω
		1 mA to 1A	1 Ω

AMPLIFIER

Bandwidth: 3 dB down at 1 Hz

Gain: $\frac{1 \text{ Volt}}{\text{Range Setting in Volts}}$ or 100,000 max.

Line-frequency Rejection: Greater than 60 dB

Response time: Less than 1 second from zero to 90% end scale for all ranges

Overload Recovery Time: Less than 1 second for all ranges

DC OUTPUT

Level: End-scale value continuously adjustable from zero to $\pm$1 V into 1000 Ω

Polarity: Same as input

Noise: P/P noise = $\frac{100}{\text{range in } \mu\text{V}}$ % of output level for end scale deflection

RMS Ripple: DC output level/ripple ratio = 40 dB, (min.)

Drift: DC output circuitry does not contribute to drift

Output Resistance: approximately 2000 ohms for all ranges.

INPUT INSULATION RESISTANCE (Floating)

Greater than 500 MΩ; input may be floated to $\pm$1000V (dc plus peak ac) with respect to chassis ground.

PRIMARY POWER

105-125 V, 60 Hz is standard. Also available at no extra cost: 105-125 V, 50 Hz; 210-250 V, 60 Hz; 210-250 V, 50 Hz.

PHYSICAL CHARACTERISTICS

Model 95A: 7-1/4" w x 9-1/4" d x 11" h; weight 13 lbs.
Model 95AR: 5-1/2" x 19" (panel size); 8-3/4" behind panel; weight 16 lbs.

SUPPLIED ACCESSORIES

Pair of 4-foot shielded test leads terminated in insulated beryllium/copper clips.

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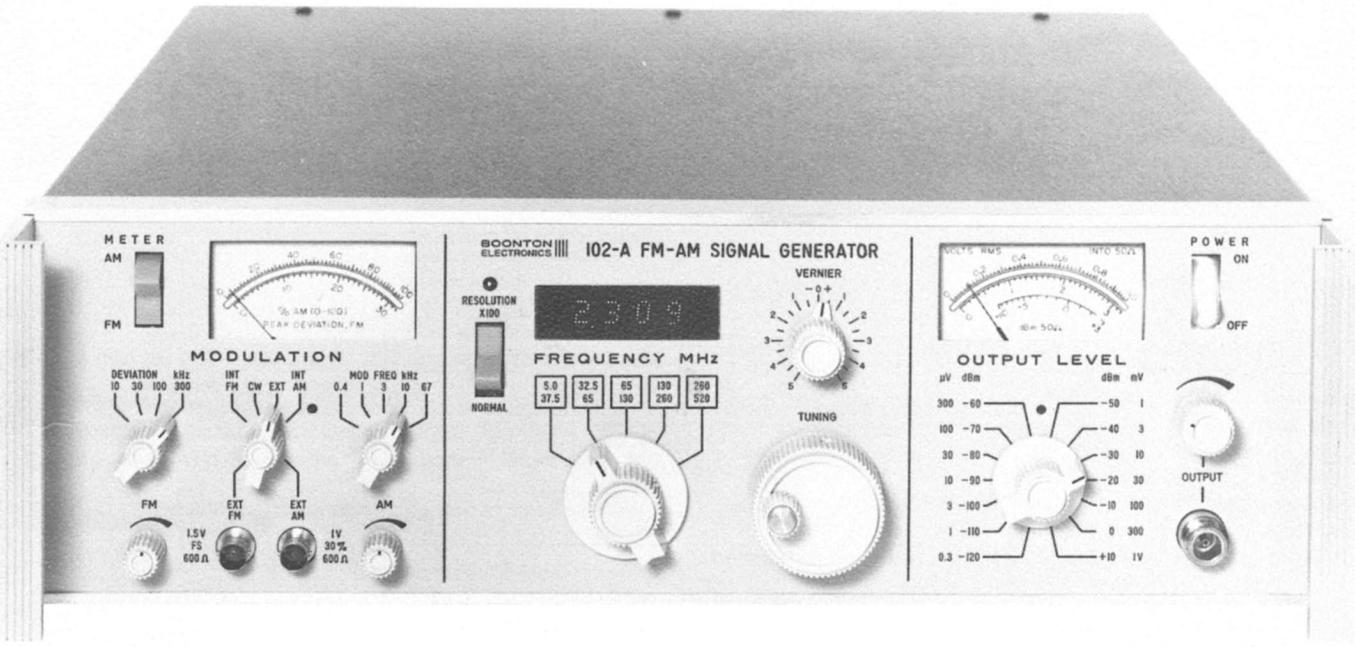
BOONTON ELECTRONICS CORPORATION
PARSIPPANY, NEW JERSEY U.S.A.

Model 102A Signal Generator

Highly Versatile FM/AM VHF Signal Generator with Digital Frequency Display.



FEATURES

- ☐ Frequency range, 5 MHz to 520 MHz.
- ☐ LED frequency display, 1 kHz resolution.
- ☐ RF output, — 130 dBm to + 13 dBm.
- ☐ Output leveled ± 0.5 dB.
- ☐ Low microphonism, residual and incidental FM.
- ☐ Electronic band-switching; no range stabilization required.
- ☐ External frequency-control input.
- ☐ Simultaneous FM and AM.
- ☐ Exceptionally wide FM deviation.
- ☐ Low distortion FM and AM.
- ☐ Wide modulation bandwidths.

INTRODUCTION

Model 102A Signal Generator provides most of the features and performance characteristics of the several available generators combined in one solid-state unit at a reasonable price.

FREQUENCY

The output frequency is derived from an inductively tuned VFO with inherently low microphonism. Electronic band-switching using PIN diodes eliminates a frequent source of instability in many generators and allows immediate use of each band without further stabilization. Its wide-band circuits do not require tracked tuning and, therefore, give the benefits of easy maintenance and good long-term stability.

Tuning mechanics have not been neglected in the Model 102A. Careful attention to bearings and reduction drives has resulted in a zero backlash system that is velvet smooth. A flywheel permits spinning the tuning control from one end of each band to the other. Drive friction is adjustable to suit the user's preference thus giving perfect "feel" without any trace of stickiness.

In addition to the smooth main tuning drive, an electronic vernier control is provided giving the utmost in fine tuning ease.

The 4 digit LED frequency display normally gives 100 kHz resolution, but may be switched to an expand mode where the first two digits overflow, thus providing a readout with 1 kHz resolution.

For maximum frequency accuracy and stability, a direct-coupled frequency-control input is provided to allow use of an external signal generator synchronizer.

MODULATION

Careful attention has been paid to optimum coupling of the varactor FM modulator to the VFO. This has achieved the low distortion necessary for wide band measurements such as required in the broadest FM and telemetry fields. Despite these capabilities the 102A also exhibits low residual and incidental FM to satisfy the stringent requirements of narrow-band applications.

FM deviation is calibrated to an exceptionally wide 300 kHz in four ranges and can be increased to over 1 MHz, uncalibrated. The FM bandwidth extends to 200 kHz, also unusual for a generator in this price range.

The output leveling loop has been additionally designed to provide negative feed-back over a portion of the AM bandwidth thus reducing distortion at the lower modulating frequencies.

Simultaneous FM and AM using both internal and external modulation sources is a useful capability of the 102A.

RF OUTPUT

The rf output level is switched in 13 steps of 10 dB each from — 130 dBm to + 10 dBm. Settings between these steps are read on the output meter which is calibrated over a 10 dB range. Output level may be set to as high as + 13 dBm for FM, CW and restricted AM use.

Output leveling is a great convenience and in this generator the output level changes less than ± 0.5 dB from one end of each band to the other.

The Model 102A is attractively packaged with convenient and easy to use controls. It offers an excellent value for its thoroughly competent and versatile performance.

SPECIFICATIONS

FREQUENCY

Ranges: 5 to 37.5 MHz
32.5 to 65 MHz
65 to 130 MHz
130 to 260 MHz
260 to 520 MHz

Accuracy: ± (1 kHz + 0.001%)

Resolution: 1 kHz

Display: Four-digit LED with normal resolution to 0.1 MHz, and x100 expansion to 1 kHz.

Stability: Drift < 30 ppm/10 min. after 1 hour warmup.

Fine Tuning: Electronic vernier, approx. 0.1% range.

External Control: DC FM input permits frequency shift with external dc level. Can be used with most signal generator synchronizers. Impedance is 5000 Ω nominal. Input levels from + 40 V to — 40V. Sensitivity approximately 25 kHz/V.

Residual FM: Band 1 < 15 Hz;
Bands 2 - 5 < 0.25 ppm.

RF OUTPUT

Power Level: — 130 dBm to + 10 dBm (Reserve output calibrated to + 13 dBm).

Attenuator: 13 steps at 10 dB/step plus variable 10 dB calibrated on output meter.

Accuracy: ± (1.0 dB + 0.15 dB/10 dB step)

Leveling: ± 0.5 dB max. variation across each band.

Spurious Outputs: Harmonics < — 30 dB.
Sub-harmonically related < — 40 dB.
Mixing products (Band 1) < — 30 dB.

MODULATION

INTERNAL MODULATION OSCILLATOR

Frequencies: 400 Hz, 1 kHz, 3 kHz, 10 kHz and 67 kHz.

Accuracy: ± 3%

Distortion: < 0.5% THD

Output: Nominal 1.0 V rms into 600 Ω (rear panel BNC connector)

FREQUENCY MODULATION

Deviation: 0 - 300 kHz peak, calibrated; 0 - 1 MHz peak, uncalibrated.

Ranges: 0 to 10 kHz peak
0 to 30 kHz peak
0 to 100 kHz peak
0 to 300 kHz peak

Deviation Accuracy: ± 10% fs

Bandwidth: 20 Hz to 200 kHz; + 0.5 dB, — 2.0 dB (ref. to 10 kHz)

Distortion: < 1% THD at 100 kHz peak deviation
< 3% THD at 300 kHz peak deviation
< 0.5% THD at 75 kHz peak deviation (100 MHz)

Ext. Mod. Input: Nominal 1.5 V rms into 600 Ω for fs deviation.

Incidental AM with FM: — 55 dB at 100 kHz deviation ($f_{mod.}$ to 1 kHz)

AMPLITUDE MODULATION

Percent: 0 to 60 minimum.

Calibrated Range: 0 to 100%

Accuracy: ± 10% of reading at 30% and 50% AM

Bandwidth: 20 Hz to 20 kHz; + 0.5 dB, — 2.0 dB (ref. to 1 kHz)

Distortion: < 1% THD at 30% AM ($f_{mod.}$ to 5 kHz)
< 3% THD at 30% AM ($f_{mod.}$ to 20 kHz)

Ext. Mod. Input: Nominal 1.0 V rms into 600 Ω for 30% AM.

Incidental FM with AM: Band 1, < 20 Hz peak at 30% AM
Bands 2 - 5, < 0.5 ppm at 30% AM

SIMULTANEOUS MODULATION CAPABILITY: External FM, internal AM
Internal FM, external AM
External FM, external AM

GENERAL

Power: 115/230 V, 50 to 400 Hz, 30 W.

Dimensions: 5¼ h, 17¼ w, 18¼ d
(13.4 cm, 43.9 cm, 46.4 cm).

Weight: 30 lbs. (13.6 kg)

Temperature: 0°C to + 50°C, operating

Accessories available: Rack Mounting Kit

Options: — 01 Modulation and RF output connectors on rear panel
— 02 Special internal modulation frequencies.

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Printed in U.S.A. 3/72 10M R.P.

102A SIGNAL GENERATOR SPECIFICATIONS

FREQUENCY

Ranges: 5 to 37.5 MHz
32.5 to 65 MHz
65 to 130 MHz
130 to 260 MHz
260 to 520 MHz

Accuracy: ± (1 kHz + .001%)

Resolution: Selectable 1 kHz, 10 kHz, 100 kHz

Display: Six-digit LED

Stability: Bands 2-5 Drift < 20 ppm/10 min. after 1 hour warmup
Band 1 Drift < 1.5 kHz/10 min. after 1 hour warmup

Fine Tuning: Electronic vernier

Band	Approx. Range
1	25 kHz
2	25 kHz
3	50 kHz
4	100 kHz
5	200 kHz

Residual FM: Bands 2-5 <0.25 ppm peak (power line frequencies)
Band 1 <15 Hz peak

RF OUTPUT

Power Level: -130 dBm to +10 dBm (reserve output calibrated to + 13 dBm).

Attenuator: 13 steps at 10 dB/step plus variable 10 dB calibrated on output meter.

Accuracy: ±(1.0 dB + .15 dB/10 dB step)

Leveling: ±0.5 dB max. variation across each band.

Spurious Outputs: Harmonics <-30 dB
Sub-harmonically related < -40 dB
Mixing products (Band 1) < -30 dB

Impedance: 50 ohms VSWR <1.5:1 at levels below 0 dBm

St. No. 3030

FREQUENCY MODULATION

Deviation: 0-300 kHz peak, calibrated; >1 MHz peak, uncalibrated

Ranges: 3 kHz, 10 kHz, 30 kHz, 100 kHz, 300 kHz peak fs

Accuracy: ±10% fs

Bandwidth: DC to 200 kHz (+0.5 dB, -2.0 dB, ref. to 10 kHz)

Distortion: Bands 3,4,5 <1% THD at 100 kHz peak dev.
Bands 1, 2 <2% THD at 100 kHz peak dev.

<0.5% THD at 75 kHz peak dev. at 100 MHz.

Ext. Mod. Input: Nominal 3 V rms into 600 ohms for fs deviation.

Incidental AM with FM: <0.25% AM at 100 kHz dev. ($f_{mod.}$ to 1 kHz)

AMPLITUDE MODULATION

Percent: 0 to 90 minimum.

Calibrated Ranges: 30%, 100% fs

Accuracy: ±3% at 30% and 50% AM (20 Hz to 20 kHz).

Bandwidth: DC to 20 kHz; + 0.5 dB, -2.0 dB (ref. to 1 kHz).

Distortion: < 2% THD at 30% AM
<5% THD at 70% AM

Typ. <2% THD at 90% AM ($f_{mod.}$ to 2 kHz).

Ext. Mod. Input: Nominal 3V rms into 600 ohms for 100% AM

Incidental FM with AM: Bands 1, 2 <40 Hz peak at 30% AM
Bands 3,4,5 <1 ppm peak at 30% AM.

INTERNAL MODULATION OSCILLATOR

Frequencies: 400 Hz, 1 kHz, 3 kHz, 10 kHz, 67 kHz.

Accuracy: ±3%

Distortion: < 0.5% THD

Output: Nominal 1.0 V rms into 600 Ω (rear panel BNC connector).

SIMULTANEOUS MODULATION CAPABILITY:
External FM, internal AM
Internal FM, external AM
External FM, external AM

GENERAL

Power: 115/230 V, 50 to 400 Hz, 30 W.

Dimensions: 5-1/4 h, 17-1/4 w, 18-1/4 d (13.4 cm, 43.9 cm, 46.4 cm).

Weight: 30 lbs (13.6 kg).

Temperature range: 0°C to + 50°C operating

Accessories supplied: Rack Mounting Kit.

Options: -01 Modulation and RF output connectors on rear panel.

-02 Special internal modulation frequencies.

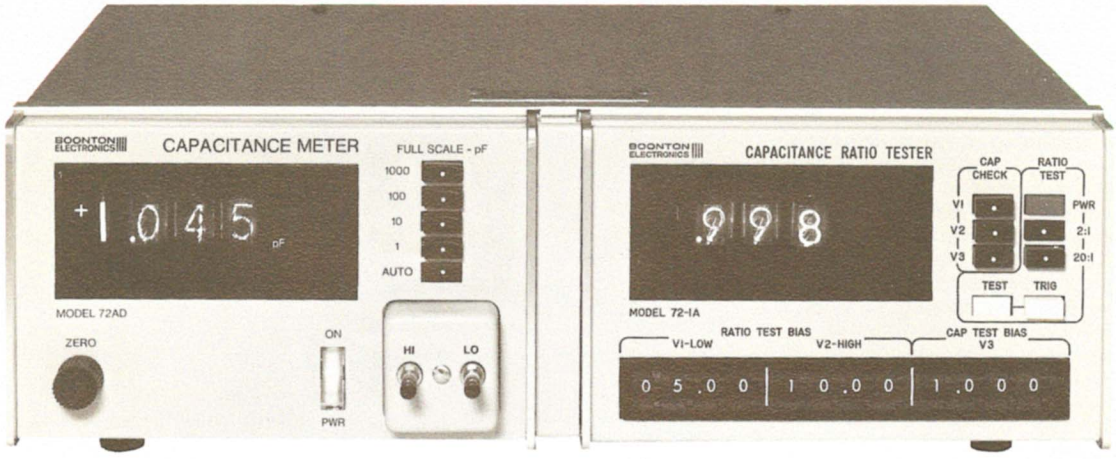
-03 Detected AM at rear panel BNC connector.

-04 Fused RF output.

BOONTON ELECTRONICS CORPORATION
PARSIPPANY, NEW JERSEY U.S.A.

Model 172A Capacitance Ratio Meter

Automatically Displays Capacitance of Voltage-Sensitive Devices at a Pre-Selected Voltage and Capacitance Ratio at Two Pre-Selected Voltages.



FEATURES

- ☐ Measures 3-terminal capacitance from 0 to 1999 pF.
- ☐ Measures capacitance ratios up to 19.99:1.
- ☐ Separate digital displays (3½ digits).
- ☐ Bias may be selected for three values 0 to 200 V.
- ☐ Capacitance accuracy: ±0.25% rdg ±0.025% fs ±1 digit.
- ☐ Ratio accuracy: ±(ratio/20)% ±1 digit.
- ☐ Bias accuracy: ±0.03%
- ☐ BCD outputs, remote control inputs.
- ☐ Automatic capacitance ranging.
- ☐ Test frequency, 1 MHz; test level, 15 mV rms.

INTRODUCTION

Rapid measurement of both 3-terminal capacitance and capacitance ratio at accurately pre-set bias levels is now available with the Model 172A. An instrument of high accuracy and utility in the laboratory, it is also invaluable for fast production-line testing (or incoming inspection) of quantities of components for compliance with specifications.

Within 500 milliseconds of activation of the test cycle, both values (ratio and capacitance) are read out on the twin digital displays. With a quick-connect test fixture, varactors, for example, can be measured almost as rapidly as they can be plugged in.

The desired maximum/minimum bias for ratio measurement are selected, with three-digit resolution, by thumb-wheel decade switch banks on the front panel. The bias for capacitance measurement is set by a third decade switch.

Automatic capacitance ranging, BCD outputs (8, 4, 2, 1), and command inputs make the 172A adaptable for integration into automated test systems.

The bias supply may be remotely programmed by a BCD code for multi-point tests of capacitance. Three bias voltages, pre-programmed on the digital switch banks, alternatively may be remotely selected by contact closures for measurement of capacitance and capacitances ratio. The capacitance-measuring section of the instrument can also be used alone for ordinary three-terminal or differential capacitance measurements within the specified range and accuracy.

The two test adapters supplied with the 172A permit either remote measurement via coaxial cables, or direct connection of wire lead components. The instrument is insensitive to external cable capacitance within limits, and the panel zero control compensates for stray test-fixture capacitance.

SPECIFICATIONS

Model 172A

Capacitance Ranges: 1.999, 19.99, 199.9, 1999 pF fs. (1, 10, 100, 1000 pF with 100% overrange)

Capacitance Accuracy:
Test Q > 5: ±(0.25% rdg + 0.025% fs + 1 digit*)
Test Q=1 to 5: ±(0.5% rdg + 0.025% fs + 1 digit*)
*add 0.005 pF on lowest range.

Ratio Ranges: 1.999:1 and 19.99:1 fs.

Ratio Accuracy: ±(ratio/20)% ±1 digit.

Test Signal: 1 MHz crystal-controlled, 15 mV rms ±2 mV.

Displays: Ratio and capacitance. Nixie-type; 3½ digits; display period 250 ms; encode period 10 ms.

Measurement time: < 500 ms.

DC Bias:

Range: 0 to 199.9 volts.

Full Scale: 1.999, 19.99, 199.9 volts.

Selection: Three banks of 3-decade digital switches with moving illuminated decimal points preset V1, V2 and V3.

Accuracy: ±(0.03% rdg + 100 μV)

Remote Programming (Capacitance and Ratio)

a) Select dc bias, pre-programmed as V1, V2, and V3 by digital switch banks, by external closure or PNP transistor to ground.
b) Select ratio range by external closure or PNP transistor to ground.
c) Start test cycle (trigger) by external closure or PNP transistor to ground.

Remote Programming (Capacitance only)

a) Select dc bias voltage by 1, 2, 4, 8 parallel BCD. Logic 0 < —0.5 V, Logic 1 > —9 V.

Data Outputs (ratio and capacitance):

Digits: 8, 4, 2, 1 code, digit parallel.

Range: Logic 0 indicates range (2 lines for ratio, 4 lines for capacitance).

Encode Complete: Transfer logic 0 to logic 1.

Overrange: Logic 0 indicates 100% fs.

Underrange: Logic 0 indicates < 9% fs (for capacitance only)

Data Commands:

Encode Hold: Logic 0 inhibits start of new encode cycle for delayed data transfer.

Encode Trigger: Transition logic 1 to logic 0 initiates encode cycle. Encoding is complete in 10 ms and digital output data is then available.

Data Logic Levels: Logic 0 < +0.5 V, logic 1 > + 3 V, TTL compatible.

Capacitance Loading Tolerances: Input configuration is three-terminal. Measurements are unaffected by capacitive loading within these limits.

a) LO post to ground: 500 pF maximum on all ranges.
b) HI post to ground:

Range	Max. C
1 pF	100 pF
10 pF	250 pF
100 pF	500 pF
1000 pF	500 pF

Dimensions: 12″ deep x 17″ wide x 5.2″ high (305 mm x 432 mm x 132 mm)

Weight: 17 lbs. (7.8 kg)

Power: 115/230 V, 50 to 400 Hz, 37 W.

Accessories Furnished: Two connection adapters:

a) BNC for remote connections to TEST and DIFF terminals.
b) Grip-posts for local connection to TEST (axial-lead components.)

Accessories Available: Rack-mounting kit 92-1B.

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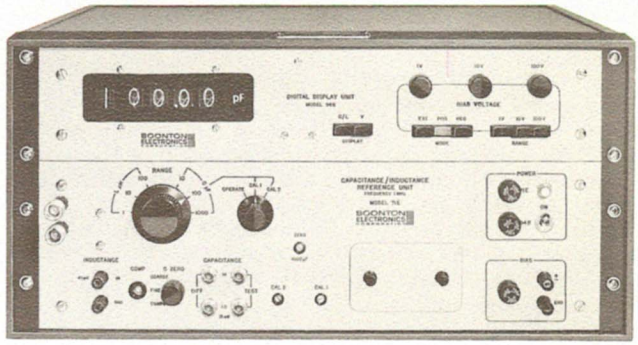
Printed in U.S.A. 5M 5-72 R.P.

BOONTON ELECTRONICS
CORPORATION
PARSIPPANY, NEW JERSEY

Model 700C Digital 1 MHz Capacitance/ Inductance Meter

Continuous, High-Resolution Measurements of Capacitance and Inductance at 1 MHz with Digital Readout.

- **Capacitance Measurements (Three-terminal)**
  Ranges: 10 pF; 100 pF; and 1000 pF fs*
  Basic accuracy ±0.3%
- **Inductance Measurements (Two-terminal)**
  Ranges: 1 μH; 10 μH; and 100 μH fs
  Basic accuracy ±1%
- **Display**
  4 digits plus "1" for 40% overrange
  Display period 200 ms (non-blinking)
- **Data Output**
  4 BCD 8-4-2-1 digits plus overrange
  Positive logic levels TTL/DTL compatible
- **Comprehensive DC Bias**
  Three presettable ± voltages, pushbutton selected
  Good regulation and overload protection
  Simplifies varactor testing
  Fused external bias input
  Accurately monitored on digital display



- **Built-in Capacitance Standard for Calibration Check**
- **Low 15 mV rms Test Signal Level**
- **1 MHz Test Frequency, Crystal Controlled**

*To 10,000 pF with accessory 71-12A Capacitance Range Extender

INTRODUCTION

The Model 700C provides precise, high resolution, three-terminal capacitance and two-terminal inductance measurements at 1 MHz with the speed and convenience of a DVM. In addition, the instrument provides a BCD output for computer interface or printer operation.

The measuring capabilities of 0 to 1000 pF and O to 100 μH are covered in six manually-operated ranges, with full scale values of 10, 100, and 1000 pF and 1, 10, and 100 μH.

Capacitance or inductance is read directly from the digital display unit. Four digit readout is available on all ranges with 40% overranging.

The 700C is a free-running system continuously measuring and displaying the test value every 200 ms. For systems use, single measurement cycles may be initiated by external command.

Model 700C comprises two basic units: Model 71E Capacitance/Inductance Meter and Model 94B Digital Display Unit, and Bias Supply.

Capacitance and inductance are measured on the 71E Capacitance/Inductance Meter. Capacitance is measured by metering the quadrature current through the test while ignoring the in-phase current; inductance measurement is accomplished by metering the quadrature voltage across the test coil while ignoring the in-phase voltage. Measurement in this fashion makes the instrument not susceptible to errors resulting from specimen loss over a wide range of Q values. The specified accuracy statements apply for Q's down to 3 for both capacitance and inductance. Devices of lower Q (to 0.1) may be measured with reduced accuracy after proper readjustment of preset controls.

CALIBRATION STANDARD

A 100 pF (±0.25%) high and low Q capacitance standard is incorporated in the Model 71E, and is switched into use by a front panel selector CAL 1/ CAL 2. This standard provides a means of calibrating the system for accurate capacitance and inductance measurements.

TEST SIGNAL

Test signal level for capacitance measurement is fixed at 15 mV rms, permitting tests on a wide variety of solid state devices including varactors. Test level for inductance measurement is less than 1 mV rms. The highly stable test signal is crystal-controlled at 1 MHz.

CAPACITANCE

The instrument measures the effective shunt capacitance of the test only. It ignores stray impedances from the LO post to ground; impedances from the HI post to ground have no significant influence on measurements above 10 pF. For values below 10 pF, the effects of capacitance from the HI post to ground are negated by adjustment of the COMP ADJ. control. Thus, the specimen can be connected to the terminals by coaxial cables, or a remote test fixture may be used without incurring errors resulting from capacitance from either side of the test to ground. For remote measurement of larger capacitance values, the Model 71-6B Capacitance Test Terminal Extender should be used. This

accessory accurately negates the effect of the series inductance of its three-foot connecting leads.

Capacitance across the test terminals contributed by an external test fixture can be zeroed out by the front panel C ZERO control for most test fixtures. Larger amounts of capacitance can be zeroed by connecting an external balancing capacitor to the DIFF posts.

By attaching samples to both the DIFF and TEST inputs, the capacitance differential between the two specimens may be measured. To increase resolution it is possible to switch down one range below the one on which the test would normally be read. Since the dc bias voltage appears at both the TEST and DIFF terminals, it is possible to measure the tracking accuracy of two varactor diodes. Using the differential technique, the scale reads directly in pF of tracking error.

CAPACITANCE RANGE EXTENSION

Capacitance measurement range may be extended to 10,000 pF by using the accessory Model 71-12A Capacitance Range Extender. When using the 71-12A, the 10 pF fs range of the 700C indicates 10,000 pF fs.

INDUCTANCE

With the inductance function selected, the 700C measures the effective 1 MHz series inductance applied between the inductance test terminals. Measurement ranges are selected manually as for capacitance. No zero setting is required for inductance. This removes the need to recheck zero during protracted measurements or range changes. Remote connection to test inductors normally requires consideration of the series inductance and shunt capacitance of the connecting leads, severely limiting accuracy. The Model 71-7A Inductance Test Terminal Extender, however, available as an accessory, accurately negates these effects of its three-foot connecting leads, allowance inductance measurements remote from the 700C INDUCTANCE test terminals.

Lower values of inductance may be read using the Model 71-10A Series of Low Inductance Adapters. Linear inductance values of 0-100 nH or 0-10 nH may be read using the 10 pF fs capacitance range of the 700C. Measurements and comparison of permeability of small toroidal magnetic cores is an additional feature of the adapters.

DISPLAY

The digital display unit uses nixie-type indicators with automatic placement of decimal point and units (pF, μH, or VDC). There is a 40% overrange capability on all ranges. If 40% of full scale on any range is exceeded, the indicator will go blank, eliminating the possibility of obtaining an erroneous or reduced accuracy reading.

DC BIAS

The internal bias supply provides a dc voltage which appears across the TEST and DIFF posts (HI and LO) of the 71E for capacitance measurements.

Three voltage ranges are provided of 0 to 1.4 V, 0 to 14 V, and 0 to 140 V.

A separate 10-turn control for each range allows each output voltage to be preset. The voltage and polarity may then be selected by pressing the appropriate pushbutton.

This is particularly advantageous for testing varactors where, for example, 4 volts and 25 volts can be preset with the two higher ranges, yielding the two corresponding values of capacitance.

The voltage regulation of each range is within 0.05% with a current limitation of 10 mA. Overload protection prevents damage to the supply or associated circuits.

In addition to the internal bias capability, an external voltage may be applied to the capacitance under test via two binding posts located on the front panel of the 71E. Any supply up to ±200 V may be used. 250 mA fusing is provided to prevent damage to equipment.

A push-button mode switch selects the function of the display unit. One button selects the normal use of the system, displaying either capacitance or inductance. The second button is used to allow the 94B to monitor the dc bias applied across the capacitance under test. A maximum of 140 VDC can be read on the display unit with full scale ranges of 1.4, 14, and 140 V for either internal or external dc bias.

SPECIFICATIONS

Capacitance Measurements (Three-terminal):
Range: 0 to 1000 pF in 3 ranges; lowest range 10 pF, fs

Accuracy: 0.25% of reading + (0.05% + $\frac{3}{Q}$ %)fs + 0.002 pF

Inductance Measurements (Two-terminal):
Range: 0 to 100 μH in 3 ranges; lowest range 1 μH, fs

Accuracy: 0.5% rdg + (0.5% + $\frac{6}{Q}$ % + $\frac{L\mu H^*}{500}$ %)fs + 0.5 nH

*Inductance value of test in μH

Test Signal:
Frequency: 1 MHz, crystal controlled ±0.02%
Level: Capacitance measurements, 15 mV rms ±1mV;
Inductance measurements, less than 1 mV rms

Display:
Type: Digital display tubes
Digits: 4 plus "1" for 40% overrange
Display period: 200 m sec (free running or ext. hold)
Measurement period: 1/15 sec
Resolution: ±1 digit

Digital Inputs/Outputs:
Logic Levels: 1 > + 3V; Z ≈ 125Ω
0 < 0.5 V; Z ≈ 50Ω } TTL
BCD Output: 8-4-2-1 4 line for each digit
Overrange: Logic 0
Blanking: Above 1.3999, logic 0
Polarity: Positive, logic 1
Encode: Start, logic 1, end logic 0
Hold: Logic 0 (input)

Q Range:
Specified performance applies for Q's down to 3, to lower Q values with reduced accuracy after readjustment.

DC Bias:
Internal: 0 to ± 140 V; 3 ranges 0-1.4 V; 0-14 V; 0-140 V individually presettable. Push buttons select range and polarity. Max. current 10 mA, regulation 0.05%
External: 0 to ±200 V at 250 mA, fused.
Bias Monitor: Reads on digital display, accuracy ± 0.1% rdg (± 2 digits)

Internal Reference Standard:
100 pF (±0.25%), provides CAL1/high Q and CAL2/low Q (Q=3) set up.

Line Voltage Influence:
± 10 V Change from 117 V: ± 0.15% rdg. max.

Ambient Temperature Influence:
Normal ambient temp. range: 23°C ± 10°C
Ambient temp. effect: ± 0.02% rdg./°C

Stability:
Min. warm-up period: 1 hr.
Typical change during 1 hr. warm-up: Indication ± 0.5% fs
Zero ± 0.2% fs
24 hrs. stability after 2 hr. warm-up: Indication ± 0.1% rdg.
Zero ± 0.1% fs

Humidity Influence:
Recommended Max. RH: 80%
Effect of prolonged (24 hrs. or more) exposure to High (95%) RH: ± 0.4% fs
Recovery period (operating) after humidity Exposure: 25 hrs.

Primary Power:
117 or 234 V (±10%), 50/60 Hz: 40 watts

Physical Specifications:
19⅝" w x 9½" h x 18" d in cabinet; with cabinet removed mounts in standard 19" rack; weight 35 lbs.

Accessories:

Model No.	
71-2A	Plug-in Capacitance Standard
71-3A	Precision Decade Capacitor
71-4A	Capacitance Range Divider
71-6B	Capacitance Test Terminal Extender
71-7A	Inductance Test Terminal Extender
71-10A/10	Low Inductance Adapter 10 nH fs
71-10A/100	Low Inductance Adapter 100 nH fs
71-12A	Capacitance Range Extender (10,000 pF)
63-15A	1μH Inductance Standard

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