

1620-A PRECISION CAPACITANCE MEASUREMENT SYSTEM

Accurate, High Precision Capacitance Measurements

- 10⁻⁵pF to 11.1 μ F, 2- or 3-terminal
- 0.01% accuracy, 1ppm resolution
- Lever balance, in-line readout
- Reads dissipation factor or conductance

The 1620-A is a self-contained assembly of the 1615-A Capacitance Bridge with appropriate oscillator and null detector for measurements at 11 frequencies between 50Hz and 10kHz. For applications requiring other or higher frequencies, to 100kHz, the 1615-A Bridge can be supplied separately and the oscillator and detector selected to meet your needs.

The 1620-A is intended for:

- Accurate and precision measurements of capacitance and dissipation factor.
- Measurement of circuit capacitances.
- Dielectric measurements.
- Intercomparison of capacitance standards differing in magnitude by as much as 1000:1.

The 1615-A Capacitance Bridge brings to the measurement of capacitance, the intercomparison of standards, and to the measurement of dielectric properties an unusual degree of accuracy, precision, range, and convenience.

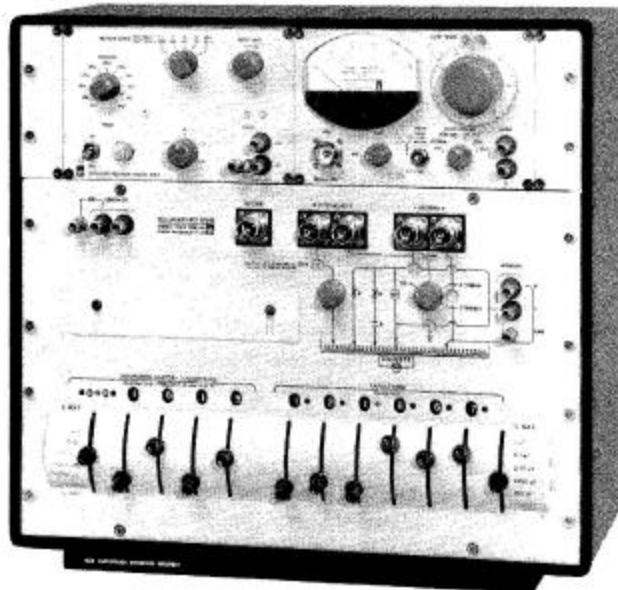
High accuracy is achieved through the use of precisely wound transformer ratio arms and highly stable standards fabricated from Invar and hermetically sealed in dry nitrogen. For calibration these standards can be intercompared.

Two- or Three-Terminal Connection – Accurate three-terminal measurements can be made even in the presence of capacitances to ground as large as 1 μ F, as might be encountered with the unknown connected by means of long cables. The bridge has the necessary internal shielding to permit one terminal of the unknown capacitor to be directly grounded, so that true two-terminal and three-terminal measurements can both be made over the whole capacitance range.

Convenient Operation – For both capacitance and dissipation factor, the balance controls are smoothly operating, lever-type switches. The readout is digital and the decimal point is automatically positioned. Each capacitance decade has a -1 position to facilitate rapid balancing.

The 1615-A elementary diagram is also clearly delineated on the front panel of the bridge. Changes in connections and grounds are automatically indicated, as you switch the bridge terminals for different measurement conditions.

Extend Range to 11.1 μ F – With the 1615-P1 Range-Extension Capacitor, the 1615-A will measure to a maximum of 11.11110 μ F. This capacitor plugs into front-panel bridge terminals and can be adjusted for calibration to the bridge standards.



SPECIFICATIONS

1620 PRECISION CAPACITANCE MEASUREMENT SYSTEM

Performance:	See 1615-A for performance specifications.	
Supplied:	1615-A Precision Capacitance Bridge. 1311-A Oscillator. 1232-A Tuned Amplifier and Null Detector. 1232-P2 Preamplifier added in 1620-AP.	
Power:	105 to 125V and 210 to 250V, 50 to 400Hz, 22W for oscillator.	
Mechanical:	Dimensions (w x h x d): Bench: 19.75 x 19 x 11in (502 x 483 x 280mm). Weight: 59lb (27kg) net, 96lb (44kg) shipping.	
Ordering Information:	Description	Catalog Number
	Precision Capacitance Measurement System	
	1620-A, 115V	1620-9701
	1620-A, 230V	1620-9702
	1620-AP, with 1232-P2, 115V	1620-9829
	1620-AP, with 1232-P2, 230V	1620-9830

1615-A CAPACITANCE BRIDGE

The 1615-A is an accurate, high-precision bridge for the measurement and intercomparison of standard capacitors, circuit component capacitors, or dielectric materials. It is available with oscillator and detector in the 1620-A system. Or, to take full advantage of its wide frequency range, the bridge can be ordered separately for use with oscillator and detector especially selected for your purposes.

Capacitance Measurement:	Range:	10aF to 1.11110 μ F (10^{-17} to 10^{-6} F) in 6 ranges, direct reading, 6-figure resolution; least count 10^{-17} F (10aF). With Range-Extension Capacitor, upper limit is 11.11110 μ F.
	Accuracy:	At 1kHz, $\pm(0.01\% + 0.00003\text{pF})$. At higher frequencies and with high capacitance, additional error is: $[\pm 3 \times 10^{-5}\% + 2(C_{\mu\text{F}}) \times 10^{-3}\% \pm 3 \times 10^{-7}\text{pF}] \times (f_{\text{kHz}})^2$ At lower frequencies and with low capacitance, accuracy may be limited by bridge sensitivity. Comparison accuracy, external standard to unknown, 1ppm.
Dissipation Factor:	Range:	At 1kHz, 0.000001 to 1, 4-figure resolution, least count, 0.000001 (10^{-6}), range varies directly with frequency.
	Accuracy:	$\pm[0.1\% \text{ of measured value} + 10^{-5} (1 + f_{\text{kHz}} + 5f_{\text{kHz}} C_{\mu\text{F}})]$.
Conductance:	Range:	$10^{-6}\mu\text{S}$ to 100 μS , 2 ranges +, 2 ranges-, 4 figure resolution, least count $10^{-6}\mu\text{S}$, independent of frequency, range varies with C range.
	Accuracy:	$\pm[1\% \text{ of measured value} + 10^{-5}\mu\text{S} + 6 \times 10^{-2}f_{\text{kHz}} C_{\mu\text{F}} \times (1 + f_{\text{kHz}} + 5f_{\text{kHz}} C_{\mu\text{F}})\mu\text{S}]$.
Frequency:	Approximately 50Hz to 10kHz. Useful with reduced accuracy to 100kHz. Below 100Hz, resolution better than 0.01% or 0.01pF requires preamplifier or special detector.	
Standards:	1000, 100, 10, 1, 0.1, 0.01, 0.001 and 0.0001pF. Temperature coefficient of capacitance is less than 5ppm/ $^{\circ}$ C for the 1000, 100, and 10pF standards, slightly greater for the smaller units.	
Generator:	Maximum safe generator voltage (30 x fkHz) volts, 300V max. If generator and detector connections are interchanged, 150 to 500V can be applied, depending on switch settings. QuadTech 1311-A Audio Oscillator is recommended.	

1232-A TUNED AMPLIFIER AND NULL DETECTOR

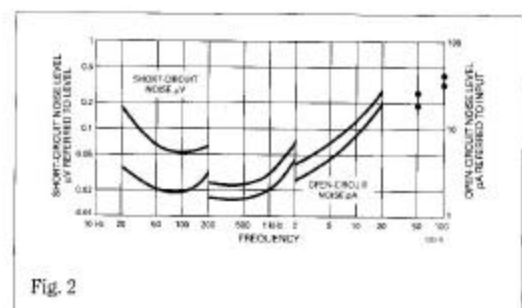
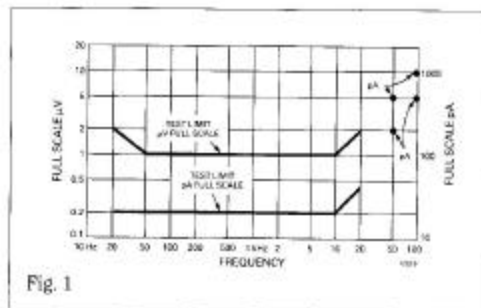
- 20Hz to 20kHz, 50 and 100kHz
- 0.1 μ V sensitivity
- Bandwidth approximately 5%
- 120dB gain

A sensitive null detector like this is the key to many a fussy bridge measurement. Battery operation frees the 1232 from power-line noise and makes it ultra portable. Low-noise solid-state circuitry and high gain make it very sensitive. Its tunability and choice of bandwidth enable you to reject broadband noise as well as the harmonics that might otherwise impair good measurements. Here are its prime uses:

- Bridge detector at audio frequencies; with the 1232-P2 Preamplifier it is equally sensitive for extremely high-impedance sources.
- Audio preamplifier and general-purpose, tunable or broadband audio amplifier.
- Sensitive audio wave analyzer for approximate measurements.

Frequency: Tunable Filters: 20Hz to 20kHz in 3 ranges, between 2% and 6% bandwidth to 15kHz. 2nd harmonic at least 34dB down from peak, 3rd harmonic at least 40dB down, rejection filter on two highest ranges reduces 60Hz level to at least 60dB below peak response (50Hz level is down >50dB). Dial accuracy is $\pm 3\%$.
 Fixed-Tuned Filters: 50kHz, 2nd harmonic is 44dB down; 100kHz, 2nd harmonic is 53dB down.
 Flat Response: ± 3 dB from 20Hz to 100kHz.

Sensitivity: See fig. 1. Typically better than 0.1 μ V over most of the frequency range.



Noise Level: Referred to input: See fig. 2. Noise at 1kHz <2dB at an optimum source impedance of 27k Ω .
 Referred to output: <5mV on FLAT filter-frequency position, min gain setting, and -20dB switch position.
 <50mV in MAX SENS position.

Signal Input: Impedance: Approximately 50k Ω at max gain; varies inversely with gain to 1M Ω at min gain.
 Max Safe Voltage: 200Vac or 400Vdc.

Output: Voltage Gain: Approximately 120dB on the tunable ranges; 100dB, flat range; 106dB at 50kHz; 100dB at 100kHz position.
 Level: 1V into 10k Ω when meter indication is full scale.
 Internal Impedance: 3k Ω .
 Meter Linearity: dB differences are accurate to $\pm 5\% \pm 0.1$ division for inputs of less than 0.3V.
 Compression: (meter switched to LOG) Reduces full-scale sensitivity by 40dB.
 Does not affect bottom 20% of scale.
 Attenuation: (meter switched to -20dB)
 Linear response with 20dB less gain than MAX SENS.

Distortion: (filter switch in FLAT position): <5% (due to meter rectifiers).

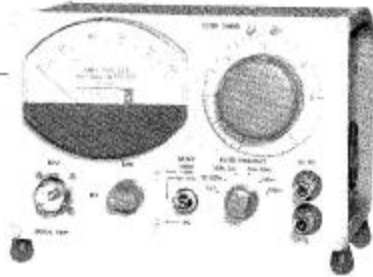
Terminals: Input: 874 Coaxial Connector. Output: binding posts.

Available: 1232-P2 Preamplifier to maintain sensitivity of 1232-A at low frequencies when operating from a source impedance above 100k Ω .

Power: 12Vdc, from 9 mercury (Eveready type E4 or equivalent) cells in series. Estimated battery life 1500 hours.

SPECIFICATIONS

Mechanical: Convertible-bench cabinet:
 Dimensions: (w x h x d): 8 x 6 x 7.5in (203 x 152 x 190mm).
 Weight: 5.75lb (2.6kg) net, 8lb (3.7kg) shipping.



Ordering Information:	Description	Catalog Number
	1232-A Tuned Amplifier and Null Detector	1232-9701
	1232-AP Tuned Amplifier and Null Detector with preamplifier	1232-9829

1232-P2 PREAMPLIFIER

The 1232-P2 has particular application to measurements with the 1615-A Capacitance Bridge. It increases sensitivity for measurements made at frequencies well below 1000Hz if the bridge is set to both its lowest C and D (not G) ranges simultaneously. Low-frequency measurement of small samples of dielectric materials can be made more accurately with the addition of this preamplifier.

Voltage Gain: Approximately 0.7.

Noise: (referred to input) Open-circuit equivalent, 0.1pA.
 Short-circuit equivalent, 0.3μV (when used with Type 1232-A tuned to 100Hz).

Impedances: Input: >100mΩ in parallel with 70pF.
 Optimum Source: 3MΩ.
 Output: 10kΩ.

Connectors: 874 on cables, input and output.

Power: 12V, 200μA, supplied by 1232-A.

Mechanical: Special Cabinet.
 Dimensions: (w x h x d): 0.75 x 6 x 7.5in (19 x 152 x 190mm).
 Weight: 0.94lb (0.43kg) net, 4lb (1.9kg) shipping.

Ordering Information:	Description	Catalog Number
	1232-P2 Preamplifier	1232-9602

MODEL 1620-A

Detector: QuadTech 1232-A Tuned Amplifier and Null Detector is recommended. For increased sensitivity needed to measure low-loss small capacitors (on lowest C and D ranges simultaneously) at frequencies below 1kHz, use the 1232-AP Tuned Amplifier and Null Detector or 1238 Detector (with 1311-A Audio Oscillator).

Connections: Gen Input; Binding posts, ground terminal with shorting link. Detector, External Std, and Unknown; 874 connectors. Unknown, 2-Terminal; Binding posts.

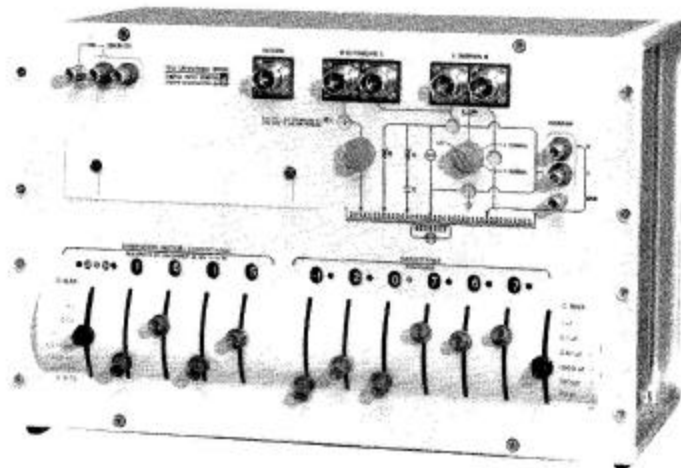
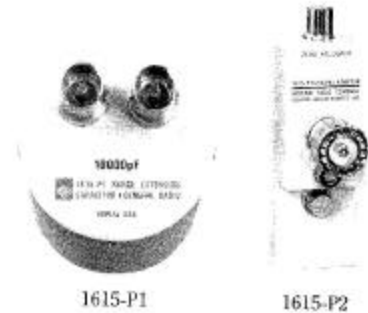
Required: Oscillator and Detector.

Supplied: 874-WO Open-Circuit Termination, 874-R22A Patch Cord, 274-NL Patch Cord.

Available: Type 1615-P1 Range Extension Capacitor
 Type 1615-P2 Coaxial Adaptor converts 2-terminal binding post connection of 1615-A bridge to G900 Precision Coaxial Connector for highly repeatable connections and enables measurements with adaptor to be direct reading by compensating for terminal capacitance.

Mechanical: Dimensions: (w x h x d): Bench: 19 x 12.75 x 10.5in (483 x 324 x 267mm);
 Rack: 19 x 12.25 x 8.5in (483 x 311 x 217mm)
 Weight: 39lb (18kg)net, 58lb (27kg) shipping.

Ordering Information:	Description	Catalog Number
	1615-A Capacitance Bridge	
	Bench Model	1615-9801
	Rack Model	1615-9811
	Accessories	
	1615-P1 Range-Extension Capacitor	1615-9601
	1615-P2 Coaxial Adaptor, G900 to binding posts	1615-9602



SPECIFICATIONS

1311-A AUDIO OSCILLATOR

- 50Hz to 10kHz, discrete frequencies
- 1W, 100V or 4A output
- Transformer output

The 1311 oscillator offers high-power output and load-matching through a multitap output transformer that ensures at least ½ watt into any load from 0.08 to 8000 ohms. Thus, it is ideal for driving impedance bridges where high sensitivity is required at extreme measurement limits and for driving directly such low-impedance devices as acoustic transducers. For bridge measurements, the shielded output-transformer secondary minimizes circulating ground currents. The 1311-A is supplied in an assembly with the 1232-A Tuned Amplifier and Null Detector as the 1240 Bridge Oscillator-Detector. The 1311-A is also included in several QuadTech impedance-measuring systems.

Frequency:	50Hz to 10kHz. Eleven fixed frequencies, 50, 60, 100, 120, 200, 400, 500Hz, 1, 2, 5 and 10 kHz. One other frequency can be added at an unused switch position. A Δf control provides $\pm 2\%$ continuous adjustment.	
Accuracy:	$\pm 1\%$ of setting with Δf control at 0.	
Stability:	(typical at 1kHz) Warmup drift, 0.3%. After warmup, 0.008% short-term (10 min), 0.02% long-term (12hr).	
Synchronization:	Input:	Frequency can be locked to an external signal. Lock range, $\pm 3\%$ per Vrms up to 10V. The Δf control functions as a phase adjustment
	Output:	Constant amplitude (1V) to drive counter or oscilloscope. Source impedance 4.7k Ω .
Output Level:	Voltage:	Continuously adjustable from 0 to 1, 3, 10, 30 or 100V open circuit (Eoc), dependent on setting of 5-position output switch.
	Current:	Continuously adjustable from 0 to 40, 130, 400, 1300 or 4000mA, into approx short circuit (Isc).
	Power:	>1.0W into matched load, >0.5W into any resistive load between 80m Ω and 8k Ω .
Output Impedance:	One to three times Eoc/Isc, depending on output amplitude. Output ungrounded.	
Distortion:	<0.5% with any linear load. Oscillator will drive a short circuit without clipping.	
Hum:	<0.01%, independent of output setting.	
Terminals:	Output, Binding Posts, ground terminal with shorting link. Sync., ¼ phone jack on side panel.	
Power:	105 to 125V or 210 to 250V, 50 to 400Hz, 22W.	
Mechanical:	Convertible-bench cabinet: Dimensions: (w x h x d): 8 x 6 x 7.75in (204 x 153 x 197mm). Weight: 6lb (2.8kg) net, 9lb (4.1kg) shipping.	

Order Information:	Description	Catalog Number
	1311-A Audio Oscillator	
	115V Model	1311-9701
	230V Model	1311-9702



1240 BRIDGE OSCILLATOR-DETECTOR

The 1232-A Tuned Amplifier and Null Detector and the 1311-A Audio Oscillator have been combined for use with audio-frequency bridges and other null-balance devices. This assembly occupies a minimum of bench space and is supplied with removable panel extensions, which adapt it for rack mounting.

The oscillator supplies 11 fixed frequencies from 50Hz to 10kHz. The detector is tunable continuously from 20Hz to 20kHz, with additional spot frequencies of 50kHz and 100kHz. The assembly is also available with the 1232-P2 Preamplifier included.

Performance: See 1232-A and 1311-A specifications.

Mechanical: Cabinet bolted together:
 Dimensions: (w x h x d): 19 x 6 x 7.75in (483 x 152 x 197mm),
 including panel extensions for rack mounting.
 Weight: 13.5lb (7kg) net, 28lb (13kg) shipping.

Ordering Information:	Description	Catalog Number
	1240-A Bridge Oscillator-Detector	
	115V Model	1240-9701
	230V Model	1240-9711
	1240-AP Bridge Oscillator-Detector	
	with preamplifier, 115V	1240-9829
	with preamplifier, 230V	1240-9839

