1621 Precision Capacitance Measurement System

The whole of precision. The 1621 represents the first major improvement in nearly a decade in ultra-precise laboratory capacitance intercomparisons and dielectric measurements. It is a completely self-contained system capable of capacitance measurements in increments as small as 0.1 aF (10^{-7} pF) and conductance measurements in increments as small as 100 aS (10^{-10} μS; equivalent to a shunt resistance of 10^{10} MΩ). Measurements are three terminal, with 2- or 3-terminal connection, and provision is also made for the connection of an external standard for comparison measurements. Such capability and precision are usually accompanied by restricted frequency and complex operation. The 1621, however, avoids these difficulties. Little degradation of performance occurs from 10 Hz to 10 kHz and operation to 100 kHz is possible. Balances are achieved by in-line readout lever switches-easily adjusted and read correctly. All digits of capacitance and conductance, as well as pertinent multipliers, are also provided by BCD-coded contact closures, available* at rear-panel connectors for use by printers or data-processing equipment.

Three integrated units. The 1621 is an assembly of three integrated instruments: A precision ratio-arm bridge, a highly stable oscillator, and an extremely sensitive detector. Most of the bridge's internal standards are enclosed in an insulated housing to reduce the effects of ambient temperature changes; unused standards are disconnected to reduce shunt capacitance at the detector input. The oscillator provides up to 125 V or 5 A for sufficient signal to be detected even with unbalances as small as one part in 10^8 of 10 pF. The detector contains three meters to help you speed the balance: One displays the magnitude and the other two simultaneously display the in-phase and quadrature components of any unbalance.

* National stock numbers are listed on the back of the catalog.

- 10^{-7} pF to 10 μF
  12-digital readout, 10-ppm basic accuracy
- 10^{-10} μS to 1000 μS
  5-digital readout, 0.1% basic accuracy
- 3-terminal measurements with 2- or 3- terminal connection
- comparison measurements
- simple lever balance with in-line readout

Model 1621 Precision Capacitance Measurement System

SPECIFICATIONS

Frequency: 10 Hz to 100 kHz.

Supplied: 1616 Precision Capacitance Bridge, 1316 Oscillator, 1238 Detector, all necessary interconnection cables, and power cord.

Available: 1408 REFERENCE STANDARD CAPACITORS (10 pF and 100 pF) for calibration.

Power: 100 to 125 and 200 to 250 V, 50 to 60 Hz, 51 W.

Mechanical: Bench or rack models.

DIMENSIONS:
Bench: 61.6 cm H x 50.2 cm W x 38.1 cm D (24.25" x 19.75" x 15"),
Rack: 53.1 cm H x 48.3 cm W x 29.1 cm D (20.91" x 19" x 11.44").

WEIGHT: Bench: 48 kg (105 lb) net, 64 kg (140 lb) shipping;
Rack: 41 kg (90 lb) net, 57 kg (125 lb) shipping.

ORDERING INFORMATION

1621 Precision Capacitance-Measurement System

1621-9701	Bench Model, 60 Hz	1621-9703	Bench Model, 50 Hz
1621-9702	Rack Model, 60 Hz	1621-9704	Rack Model, 50 Hz

1616 Precision Capacitance Bridge

The heart of precision. The 1616 is the heart of the 1621 Capacitance-Measuring Assembly. The bridge is also available separately for use where oscillator and detector are on hand or in applications in which they must be specialized for a unique need.

The 1616 employs a transformer ratio-arm bridge with which unbalances as small as 0.1 aF (10^{-7}pF) and 100 aS(10^{-10} μS) can be resolved. Detection of such small unbalances is aided by ratio-transformer voltage capabilities up to 160 volts at 1 kHz and by range switching that disconnects the unused internal standards in order to reduce shunt capacitance across the detector input.

For thermal stability in precision intercomparisons, eight of the twelve internal capacitance standards are mounted in an insulated compartment to reduce the effects of ambient temperature changes. Misreading the values at balance is virtually impossible due to direct-reading lever switches that control the balance for both capacitance and conductance. Panel layout is unusually neat-only the unknown capacitor and , if desired, and external standard for comparison measurements are connected to the front panel; the oscillator and detector are connected to the rear as are the BCD data-output channels.

Model 1616 Precision Capacitance Bridge

- 10^{-7} pF to 10 μF - 12 digital readout
- 10^{-10} μS to 1000 μS- 5 digital readout
- 10 Hz to 100 kHz
- up to 150-V input from oscillator
- 3-terminal measurements
- coaxial measurements

SPECIFICATIONS

Capacitance measurement, 3-terminal; DECADES: 12. RANGE: 0.1 aF to 1 μF (10^{-19} to 10^{-6} F). ACCURACY:* ±10 ppm, when most-significant decade is 1, 10, or 100 pF per step; otherwise, and at other frequencies, accuracy is ±[50ppm + (0.5 + 20 $C_{\mu F}$) (f_{kHz} ppm + (f_{kHz}) aF].
Capacitance, 2-terminal: Same as above, except as follows. RANGE: One additional decade, to 10 μF (10^{-19} to 10^{-5} F).
Conductance measurement, 3-terminal: DECADES: 5 (virtually extended to 11 by G multiplier). RANGE; 100 aS to 100 μS (10^{-16} to 10^{-4} S). ACCURACY:* ±(0.l% + 1 step in least significant decade). There is a small reduction in conductance accuracy at frequencies other than 1 kHz. RESIDUAL C (across conductance standards): ±(<0.03 pF).
Conductance, 2-terminal: Same as above, except as follows: RANGE: One additional decade, to 1000 μS(10^{-16} to 10^{-3} S).
Multipliers: FOR 3-TERM: X1. X10; FOR 2-TERM: X1, X10, X100; affect both C and G. FOR CONDUCTANCE ONLY: X1, $X10^{-1}$, . . . $X10^{-6}$ (7 positions). Effects of these multipliers are included in the specified ranges.
Frequency: 10 Hz to 100 kHz.
Standards: CAPACITANCE; Air dielectric with TC < +20 ppm/ °C and D <10 ppm for 8 lowest decades; Invarf, air dielectric with TC of +3 ±1 ppm/ °C and D <10 ppm for 3 middle decades; mica dielectric with TC of 20 ±10 ppm/°C and D <200 ppm for 2 highest decades. ADJUSTMENTS for all capacitance standards available through key-locked door on panel. THERMAL LAG: C standards for first 8 decades mounted in an insulated compartment with a thermal time constant of 6 h (time required for compartment interior to reach 63% of ambient change). CONDUCTANCE: Metal-film resistors in T networks with small phase angles.
Comparison: Terminals provided to connect external standard for comparison measurements; 13-position panel switch multiplies standard by -0.1,0 ... +1.

Input: The smaller of 160 f_{kHz} or 350 V rms can be applied to the bridge transformer at the GENERATOR terminal without waveform distortion; 500 V rms max, depending on conductance range, when GENERATOR and DETECTOR connections are interchanged.
Interface: GR900® locking coaxial connector on panel to connect 2-terminal unknowns, 2 gold-plated GR900® locking coaxial connectors on panel to connect 3-terminal unknowns and 2 to connect external standard. DATA OUTPUT; 50-pin and 36-pin type 57 connectors on rear provide connection to 8-4-2-1 weighted BCD contacts (rated at 28 V, 1 A) on each switch for capacitance and conductance values respectively.
OSCILLATOR and DETECTOR: Connect to rear BNC connectors.
Required: OSCILLATOR: GR 1316 recommended. DETECTOR: GR 1238 recommended. The 1616 Bridge is available with this oscillator and detector as the 1621 Capacitance-Measuring Assembly.
Available: 1316 OSCILLATOR, 1268 DETECTOR, a broad line of capacitance and resistance standards, and coaxial cables for connection of unknowns and standards.

* Accuracy stated as fraction of measured value, for these conditions; frequency, 1 kHz, except as noted, temperature, 23° ± 1°C; humidity, <50%RH.
t Registered trademark of the Carpenter Steel Co.
National stock numbers are listed at the back of the catalog.

Mechanical: Bench or rack model. DIMENSIONS:
Bench: 35.1 cm H x 50.2 cm W x 32.7 cm D (13.81" x 19.75" x 12.88")
Rack: 31.0 cm H x 48.3 cm W x 26.8 cm D (12.22" x 19" x 10.56").
WEIGHT: Bench, 26 kg (57 lb) net, 32 kg (69 lb) shipping; rack, 23 kg (49 lb) net, 28 kg (61 lb) shipping.
Ordering: 1616-9700 Bench Model
1616-9701 Rack Model

Precision Capacitance Measurement System

1238 Detector

Designed for the difficult. If you've ever had to extract a small signal from noise or to resolve a signal into its in-phase and quadrature components, you can appreciate the advantages of the 1238. With its high gain -130 dB-and meters not only for magnitude of the input signal but for the in-phase and quadrature components as well, the 1238 lends itself handily to the most exacting applications.

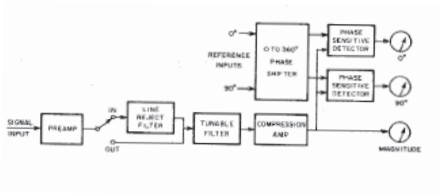
This high-performance detector is attractive in other respects also, including 1-GΩ input impedance for minimum loading, overload protection against signals up to 200 V. and flat or tuned frequency response (with or without line-frequency rejection) to tailor the detector to your signal no matter how "tainted" it might be.

Excellent bridge detector. In combination with a special oscillator, GR 1316, that supplies the necessary quadrature reference channels, this detector is superb for sensitive audio-frequency detectlbn. The combination is specifically intended for use with the 1616 Precision Capacitance Bridge, enabling resolutions of one part in 10^6 of 10 pF. Refer to the 1621 Precision CapacitanceMeasurement System.

The 1238 Detector consists of a high-impedance low-noise preamplifier, a tuned amplifier, a compression amplifier, and two phase-sensitive detectors. Three panel meters provide the indications: one displays the magnitude of the input signal and two others simultaneously display its in-phase and

quadrature components. The reference signals can be rotated continuously from 0 through 360° to ensure that the phase meters respond independently to the components of significance to you, for the most rapid bridge balances or signal analysis.

The effects of noise, hum, or any other input-signal contaminants are normally reduced or eliminated from your measurements by means of a tunable filter, line-rejection filter, and selectable time constants in the phase-sensitive detector circuits - all controlled from the front panel by the simple push of a button or turn of a knob.



- 10 Hz to 100 kHz
- 100-nS full-scale sensitivity
- magnitude, in-phase, and quadrature meters for rapid bridge balances
- excellent bridge detector

SPECIFICATIONS

Frequency: 10 Hz to 100 kHz, flat or tuned. FLAT: ±5 dB from 10 Hz to 100 kHz. TUNED: Set by 4 in-line readout dials with ±5% of reading accuracy, 2 to 4% bandwidth, and second harmonic 30 dB down from peak. LINE-REJECTION FILTER: Reduces line level by 40 dB while signal is down 6 to 10 dB at 10 Hz from line frequency; filter can be switched out.

Signal Input from bridge or other source: Applied to rear BNC-connector. SENSITIVITY: Also see curve; 100 nS rms typical for full-scale deflection at most frequencies, compression can be switched in to reduce full-scale sensitivity by 20 dB. IMPEDANCE: 1 GΩ//20 pF. MAXIMUM INPUT: 200 V rms. VOLTAGE GAIN: ~105 dB in flat mode, ~130 dB in tuned mode. set by 12-position switch. SPOT NOISE VOLTAGE: <30 nS x $\sqrt{\text{bandwidth}_{Hz}}$ at 1 kHz with input impedance of 70 MΩ//500 pF. MONITORED by magnitude, in-phase, and quadrature meters; phase-sensitive detectors contain time-constant vairable from 0.1 to 10 s in 5 steps.

Reference Inputs from oscillator: Applied to rear BNC connectors. Two 1-V rms reference signals required, with 90° phase difference between them. PHASE SHIFTER rotates both references continuously from 0 to 360° and two verniers rotate each reference individually ~10°.

Outputs: MAIN AMPLIFIER: 4 V rms (approx 2.3 V for full scale on Magnitude meter) available at rear BNC connector. MAGNITUDE: 6 V dc for full scale deflection; PHASE DETECTORS: Up to 1 V dc each for full scale deflection (depending on Sensitivity setting); available at rear 5-pin type 126 jack.

Environment: TEMPERATURE: 0 to +55°C operating, -40 to +75°C storage. BENCH HANDLING: 4 in. or 45° (MIL-810A-VI). SHOCK: 30 G, 11 ms (MIL-T-4807A-4.5-3A).

Required: Oscillator with 0 and 90° outputs; the 1316 Oscillator is recommended.

Power: 100 to 125 and 200 to 250 V. 50 to 60 Hz. 15 W.

Mechanical: Bench or rack models.

DIMENSIONS:
Bench: 16.9 cm H x 49.7 cm W x 32.9 cm D (6.66"x19.56"x12.94")
Rack, 13.3 cm H x 48.3 cm W x 33.2 cm D (5.22"x19"x13.06").

WEIGHT: Bench: 13 kg (27 lb) net, 19 kg (40 lb) shipping, rack 10 kg (21 lb) net, 16 kg (34 lb) shipping.

ORDERING: 1238-9700 60-Hz Bench Model
1238-9701 60-Hz Rack Model
1238-9703 50-Hz Bench Model
1238-9704 50-Hz Rack Model

IET LABS, INC. in the GenRad Tradition
534 Main Street, Westbury, NY 11590
www.ietlabs.com
TEL: (516) 334-5959 • (800) 899-8438 • FAX: (516) 334-5988

Precision Capacitance Measurement System

1316 Oscillator

Convenience and performance Set four controls and the 1316 provides any frequency from 10 Hz to 100 kHz with 1% accuracy and with little chance of an improper setting-the dials provide in-line readout, including decimal point and frequency units. Set two more controls, and the 1316 provides up to l.6 watts of output power (125 V open circuit or 5 A short circuit), low distortion, and accurate metering.

These features alone would qualify the 1316 as an excellent general-purpose oscillator but it offers more: Output constant within ±2%. excellent stability (only 0.005% drift over a 12-hour period), and a synchronizing feature that allows the oscillator to be locked to an external standard for even greater accuracy and stability.

Excellent bridge oscillator The 1316 is a high-performance bridge oscillator specifically intended for use with the 1238 Detector and the 1616 Precision Capacitance Bridge. The oscillator supplies 2 references (in quadrature) for the 2-phase phase-sensitive detector, which enables you to make independent and ultra-precise balances of the conductance (real part) and capacitance (imaginary part) of capacitive devices.

The 1316 contains a Wien-bridge oscillator isolated from the load by a low-distortion transformer coupled power amplifier. The oscillator circuit includes a provision to introduce a synchronizing signal for phase locking or to extract a signal, independent of the output setting, to operate a counter or to synchronize an oscilloscope.

Model 1316 Oscillator

- 10 Hz to 100 kHz
- up to 125 V or 5-A output
- output level adjustable and metered
- in-phase and quadrature reference outputs
- in-line readout dials
- current-limited output - short circuits OK

SPECIFICATIONS

Frequency: 10 Hz to 100 kHz in 4 decade ranges. Controlled by one 11-position and one 10-positron switch for the most significant digits and a continuously adjustable dial with detented zero position for the third digit; in-line readout with decimal point and frequency units.

Accuracy: ±1% of setting with continuously adjustable dial at zero detent position. DRIFT (typical at 1 kHz): Warmup 0.1%, short-term (10 min) 0.001%, long-term (12 h) 0.005%. RESETTAB1L1TY: Within 0.005%.

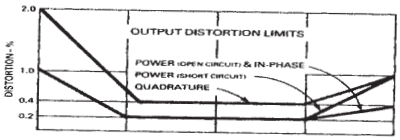
National stock numbers are listed at the back of the catalog.

Power Output: CONTROLLED by 5-position switch and uncalibrated vernier. MONITORED by meter with ±3% accuracy. AVAILABLE at rear BNC connector.

Output Range	1.5 V	5 V	15 V	50 V	150 V
Open Circuit E, rms	≥1.25 V	≥4 V	≥12.5 V	≥40 V	≥125 V
Distortion	<0.2% from 100 Hz to 10 kHz				
Hum	0.003% of max output				
Response	output constant within ±2% from 10 Hz to 100 kHz*				
Short Circuit I	5 A	1.6 A	0.5 A	0.16 A	0.05 A
Distortion	<0.2% from 100 Hz to 10 kHz				
Impedance	0.25 Ω	2.5 Ω	25 Ω	250 Ω	2.5 kΩ
Power	1.6 W max into matched load				

* ±5% for outputs >30 V rms at frequencies >50 kHz.

Reference Outputs: Quadrature output lags in-phase output by 90°. Each available at rear BNC connectors.



	In-Phase	Quadrature
Output, open-circuit	1.25 ± 0.25 V rms	
Distortion, 100 Hz to 10 kHz	<0.2%	<0.4%
Response, 10 Hz to 10 kHz	±2%	
Response, 10 kHz to 100 kHz	±4%	
Minimum Load	47 kΩ	

Synchronization: INPUT: Frequency can be locked to external signal; lock range, ±1% V rms input up to 10 V; frequency controls function as phase adjustment. OUTPUT: 0.3 V rms behind 27 kΩ; useful to sync oscilloscope or to drive a counter or another oscillator. Single rear BNC connector serves as both input and output terminal.

Power: 100 to 125 and 200 to 250 V, 50 to 60 Hz. 36 W.

Mechanical: Bench or rack mount.

Dimensions:
Bench: 12.7 cm H x 50.2 cm W x 33.2 cm D (5"x19.75"x13.06");
Rack: 8.8 cm H x 48.3 cm W x 29.1 cm D (3.47"x19"x11.44").

Weight: Bench: 12 kg (26 lb) net, 15 kg (32 lb) shipping,
Rack: 10 kg (21 lb) net, 12 kg (27 lb) shipping.

Ordering: 1316 Oscillator
1316-9700 Bench Model
1316-9701 Rach Model