



## 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 ( $10^{-10}$   $\mu$ S; equivalent to a shunt resistance of  $10^{10}$  M $\Omega$ ). 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-

- $10^{-7}$  pF to 10  $\mu$ F  
12-digital readout, 10-ppm basic accuracy
- $10^{-10}$   $\mu$ S to 1000  $\mu$ S  
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

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.



### 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  
1621-9702 Rack Model, 60 Hz

1621-9703 Bench Model, 50 Hz  
1621-9704 Rack Model, 50 Hz



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## 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.

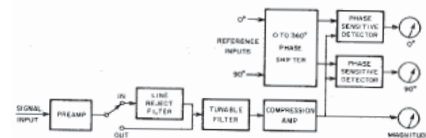
**Excellent bridge detector.** In combination with a special oscillator, GR 1316, that supplies the necessary quadrature reference channels, this detector is superb for sensitive audio-frequency detection. The combination is specifically intended for use with the 1616 Precision Capacitance Bridge, enabling resolutions of one part in 10<sup>6</sup> of 10 pF. Refer to the 1621 Precision Capacitance Measurement 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 √bandwidth<sub>Hz</sub> 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 variable 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



## 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 1.6 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  $\pm 2\%$ , 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,

- 10 Hz to 100 kHz
- up to 125 V or 5-A output
- output level adjustable and metered

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

- 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-position 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:  $\pm 1\%$  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%. RESETTABILITY: Within 0.005%.

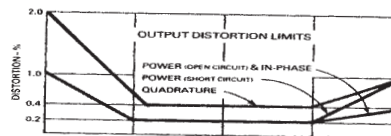
National stock numbers are listed at the back of the catalog.

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

Output Range	1.5 V	5 V	15 V	50 V	150 V
Open Circuit E, rms	$\geq 1.25$ V	$\geq 4$ V	$\geq 12.5$ V	$\geq 40$ V	$\geq 125$ V
Distortion	$< 0.2\%$ from 100 Hz to 10 kHz				
Hum	0.003% of max output				
Response	output constant within $\pm 2\%$ 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 $\Omega$	2.5 $\Omega$	25 $\Omega$	250 $\Omega$	2.5 k $\Omega$
Power	1.6 W max into matched load				

\*  $\pm 5\%$  for outputs  $> 30$  V rms at frequencies  $> 50$  kHz.

Reference Outputs: Quadrature output lags in-phase output by  $90^\circ$ . Each available at rear BNC connectors.



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

Synchronization: INPUT: Frequency can be locked to external signal; lock range,  $\pm 1\%$  V rms input up to 10 V; frequency controls function as phase adjustment. OUTPUT: 0.3 V rms behind 27 k $\Omega$ ; 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 Rack Model

