

1409 Series

Capacitance Standard Operation Manual



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1409 im/May 2022

◆ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ◆



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WARRANTY

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

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

Safety Symbols

General definitions of safety symbols used on the instrument or in manuals are listed below.



Caution symbol: the product is marked with this symbol when it is necessary for the user to refer to the instruction manual.



Hazardous voltage symbol: the product is marked with this symbol when high voltage maybe present on the product and an electrical shock hazard can exist.



Indicates the grounding protect terminal, which is used to prevent electric shock from the leakage on chassis. The ground terminal must connect to earth before using the product



Direct current.



Alternating current.



Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.



On supply.



Off supply.



Hot surface. Avoid contact. Surfaces are hot and may cause personal injury if touched.

Disposal



Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC

This product complies with the WEEE Directive (2002/96/EC) marking requirements.

The affixed label indicates that you must not discard this electrical/ electronic product in domestic household waste.

Product Category: With reference to the equipment types in the WEEE directive Annex 1, this product is classified as a “Monitoring and Control instrumentation” product.

Do not dispose of electrical appliances as unsorted municipal waste, use separate collection facilities.

Contact your local government for information regarding the collection systems available. If electrical appliances are disposed of in landfills or dumps, hazardous substances can leak into the groundwater and get into the food chain, damaging your health and well-being.

When replacing old appliances with new one, the retailer is legally obligated to take back your old appliances for disposal.

Proposition 65 Warning for California Residents



WARNING: Cancer and Reproductive Harm - www.P65Warnings.ca.gov.

This product may contain chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm

SAFETY PRECAUTIONS

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific WARNINGS elsewhere in this manual may impair the protection provided by the equipment. Such noncompliance would also violate safety standards of design, manufacture, and intended use of the instrument.

IET Labs assumes no liability for the customer's failure to comply with these precautions.

If an instrument is marked CAT I (IEC Measurement Category I), or it is not marked with a measurement category, its measurement terminals must not be connected to line-voltage mains.

The 1409 is an indoor use product.



Comply with all WARNINGS - Procedures throughout in this manual and instructions on the instrument prevent you from potential hazard. These instructions contained in the warnings must be followed.



- DO NOT Operate in an Explosive Atmosphere
- Do not operate the instrument in the presence of inflammable gasses or fumes
- Operation of any electrical instrument in such an environment clearly constitutes a safety hazard
- Use Caution around live circuits and whenever hazardous voltages > 45 V are present
- Operators must not remove instrument covers
- Component replacement and internal adjustments must be made by qualified maintenance personnel only
- DO NOT substitute parts or modify the instrument
- When working with high voltages; post warning signs, train personnel and keep unauthorized personnel away.

Do not apply any voltage or currents to the terminals of the instrument in excess of the maximum limits indicated in the specifications section of this manual.

To avoid the danger of introducing additional hazards, do not install substitute parts or perform unauthorized modifications to the instrument.

Return the instrument to an IET Labs for service and repair to ensure that safety features are maintained in operational condition.



WARNING



OBSERVE ALL SAFETY RULES
WHEN WORKING WITH HIGH VOLTAGES OR LINE VOLTAGES.

**Dangerous voltages may be present inside this instrument. Do not open the case
Refer servicing to qualified personnel**

HIGH VOLTAGES MAY BE PRESENT AT THE TERMINALS OF THIS INSTRUMENT

WHENEVER HAZARDOUS VOLTAGES (> 45 V) ARE USED, TAKE ALL MEASURES TO
AVOID ACCIDENTAL CONTACT WITH ANY LIVE COMPONENTS.

USE MAXIMUM INSULATION AND MINIMIZE THE USE OF BARE
CONDUCTORS WHEN USING THIS INSTRUMENT.

Use extreme caution when working with bare conductors or bus bars.

WHEN WORKING WITH HIGH VOLTAGES, POST WARNING SIGNS AND
KEEP UNREQUIRED PERSONNEL SAFELY AWAY.



CAUTION



DO NOT APPLY ANY VOLTAGES OR CURRENTS TO THE TERMINALS OF THIS
INSTRUMENT IN EXCESS OF THE MAXIMUM LIMITS INDICATED ON
THE FRONT PANEL OR THE OPERATING GUIDE LABEL.

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Chapter 1

INTRODUCTION

1.1 Introduction

The 1409 Standard Capacitors (Figure 1-1) consist of highly stable mica capacitors. They are used as two or three-terminal reference or standards in a laboratory.

Typical capacitors, observed over decades, have shown a stability of $<\pm 0.01\%$ in measured capacitance with no systematic drift.

The capacitors are made out of silvered-mica and foil, spring-held in a heavy metal camp for mechanical stability. The units are heat-cycled for stability, placed in a cast aluminum case with silica gel for continuous desiccation, and sealed with high-temperature potting compound.

A well is provided in the wall of the case for inserting a dial-type thermometer. For convenient parallel connection without error, three jack-top binding posts are provided on the top case, with removable plugs on the bottom.



Figure 1-1: 1409 Series Capacitance Standards

Chapter 2

SPECIFICATIONS

For convenience to the user, the pertinent specifications are given in a label, shown in Figure 2-3 affixed to the case of the instrument.

Specifications

Nominal value	Model	Initial Adjustment to nominal*	Temperature coefficient (ppm/°C)	Calibration frequency	Dissipation (typical)	Stability (per year)	Max voltage		Terminals	Capacitor type
							Peak (V)	Max Frequency		
1 nF	1409-F	±0.02%	20	1 kHz	0.0003	±100 ppm	500	10 kHz	2 bp's + gnd	Silvered Mica mechanically stabilized hermetically sealed
10 nF	1409-L	±0.02%	20	1 kHz	0.0003	±100 ppm	500	10 kHz		
100 nF	1409-T	±0.02%	20	1 kHz	0.0003	±100 ppm	500	10 kHz		
1 μF	1409-Y	±0.02%	20	1 kHz	0.0002	±100 ppm	500	10 kHz		
10 μF	1409-10μF	±0.04%	±50	100 Hz	0.0005	±200 ppm	22 Vrms†	1 kHz	4 bp's + gnd	Metallized Polypropylene Sulfide (MPPS) hermetically sealed
100 μF	1409-100μF	±0.05%	±50	100 Hz	0.001	±500 ppm	22 Vrms†	1 kHz		
1,000 μF	1409-1000μF	±0.4%	-150	100 Hz	0.001	±500 ppm	22 Vrms†	1 kHz		
Custom	1409-X	customer-selected value and power specifications								

† Maximum allowable Vrms; subject to maximum Vdc = 50 V and max Vrms = (39000/f) for C = 10 μF;

(26000/f) for C = 19 μF; (13000/f) for C ≤ 100 μF, where f = frequency (in Hz).

* Initial Adjustment to nominal is only applicable when manufactured

Calibration and Test Conditions:

Calibrated at 23°C, <50% RH, Traceable to SI

1 nF - 1 μF: Units are calibrated as both 2-terminal and as 3-terminal capacitors. For 2-terminal measurements, the **LO** terminal is shorted to the **GND** terminal. The **Adjustments to Nominal** specified in the table above apply to 2-terminal measurements.

10 μF - 1000 μF: Units are calibrated as 5-terminal capacitors, "series model"

Series Inductance:

for **0.01 μF - 1 μF:** typically < 0.06 μH

Series Resistance:

for **0.01 μF - 0.1 μF:** 0.02 Ω

for **1 μF:** 0.03 Ω

Frequency Characteristics:

Varies as \sqrt{f} above 100 kHz. See figure 1.

Leakage Resistance:

5,000 ohm-Farads or 100 GΩ, whichever is less

Environment:

Operating: +10 to +40°C, <80% RH

Storage: -20 to +65°C

1409 Mechanical Information:

Values	Dimensions	Weight
1 nF - 100 nF	10.2 cm H x 8.3 cm W x 5.1 cm D (4.0" x 3.3" x 2.0")	0.6 kg (1.25 lb)
1 μF	14.3 cm H x 8.3 cm W x 6.9 cm D (5.6" x 3.2" x 2.7")	1.1 kg (2.25 lb)
10 μF - 100 μF	8.6 cm H x 10.5 cm W x 12.7 cm D (3.4" x 4.15" x 5.0")	0.73 kg (1.6 lb)
1,000 μF	31 cm W x 8.9 cm H x 10.2 cm D (12.2" x 3.5" x 4")	1.7 kg (3.8 lb)

Frequency characteristics:

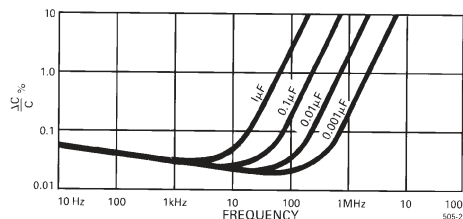


Figure 2-1: Change in capacitance as a function of frequency

Dissipation characteristics

See figure 2-2 and table above.

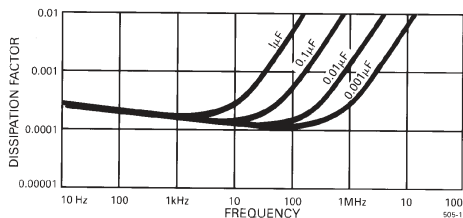


Figure 2-2: Dissipation factor as a function of frequency

SCA CAPACITANCE STANDARD		
Capacitor Type: Silvered mica and foil pile, spring-held in a heavy metal clamping structure for mechanical stability.		
Calibration: Measured value is capacitance added when standard is plugged directly into binding posts.		
Stability: <0.01% per year.		
Temperature Coefficient of Capacitance: +20 ppm/°C, between 10° and 50°C.		
Leakage Resistance: 5000 ohm-farads or 100 GΩ.		
	IET LABS, INC.	Westbury, NY 11590
	formerly manufactured by GenRad	• (516) 334-5959 • www.ietlabs.com

Figure 2-3: Sample label attached to a 1409 unit

Chapter 3

OPERATION

3.1 Initial Inspection and Setup

This instrument was carefully inspected before shipment. It should be in proper electrical and mechanical order upon receipt.

To provide ready reference to specifications, a label, shown in Figure 2-3, is attached to the case of the instrument.

3.2 Connections to Capacitor

1 nF - 1 μ F 1409 capacitors have 3 binding posts -- **HI**, **LO**, and **GND** -- as shown in figure 3-1.

10 μ F - 1000 μ F 1409 capacitors have 5 binding posts -- **Sense HI**, **Current HI**, **Sense LO**, **Current LO** and **GND** -- as shown in figure 3-2 and 3-3.



Figure 3-2: 10 and 100 μ F standard Capacitors



Figure 3-3: 1000 μ F capacitor Standard



Figure 3-1: 1409 capacitor standards

3.3 Environmental Conditions

3.3.1 Operating Temperature

For optimal accuracy, 1409 models should be used in an environment of $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$. They should be allowed to stabilize at those temperatures after any significant temperature variation.

3.3.2 Storage Temperature

The 1409 units should be maintained within the storage temperature range of 0°C to 40°C to retain its accuracy within the specified limits.

3.4 Shipping and Handling

The 1409 Series should not be exposed to any excessive shock or temperature extremes.

Chapter 4

MAINTENANCE

4.1 Preventive Maintenance

Keep the unit in a clean environment. This will help prevent possible contamination.

The 1409 is packaged in a closed case, which limits the entry of contaminants and dust into the instrument.

4.2 Calibration

The 1409 units may be employed as stand-alone instruments or as an integral components of a system. If used as part of a system, they should be calibrated as part of the overall system to provide an optimum system calibration.

4.2.1 Calibration Interval

The recommended 1409 Series calibration interval is twelve (12) months.

The calibration procedure may be carried out by the user if a calibration capability is available, by IET Labs, or by a certified calibration laboratory.

If the user should choose to perform this procedure, then the considerations below should be observed.

4.2.2 General Considerations

It is important, whenever calibrating the 1409 unit, to be very aware of the capabilities and limitations of the test instruments used.

Recommended Instruments:

- **IET Model 1689 Digibridge** (direct reading)
or
- **IET Model 1620 or 1621 Precision Capacitance Measurement System** (bridge)

The test instruments must be significantly more accurate than $\pm 0.02\%$ for all ranges, allowing for a band of uncertainty of the instrument itself.

It is important to allow both the testing instrument and the 1409 to stabilize for a number of hours at the nominal operating temperature of 23°C, and at nominal laboratory conditions of humidity. There should be no temperature gradients across the unit under test.

4.2.3 Calibration Procedure

To calibrate the 1409, proceed as follows

1. Determine and employ proper metrological practices.
Allow a confidence band for the uncertainty of the measuring instrument and setup.
2. Set test conditions:
See Calibration conditions in Specifications Chapter 2 above.
If a Digibridge is used, set to 1 Vrms, series model.
Calibrated value is the capacitance added when the standard is plugged into binding posts.
3. Determine the allowable drift limits for the capacitance reading.
<0.1% per year
4. Confirm that the readings fall within these drift limits, allowing for the uncertainty band.
If the reading falls outside the limits, the unit may need to be monitored or returned to IET,

There are no adjustments in the 1409.

4.3 Replaceable Parts List

Reference	IET Pt No	Description
1	32-21	Binding Post, Red
2	32-20	Binding Post, Black
3	32-19	Binding Post, Gold
3	BP-1000-RED	Binding Post, Red
3	BP-1000-BLK	Binding Post, Black
3	BP-1000-GRN	Binding Post, Green
Not Shown	UG-194	bnc connecor
Not Shown	SCA-*Cap	SCA capacitor assembly

Replace * with nominal capacitance value

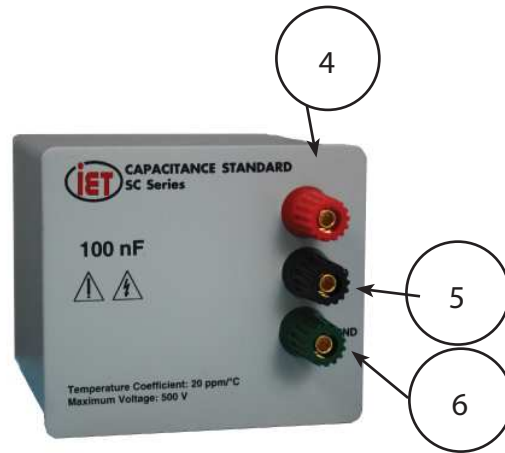


Figure 4-1 10 μ F - 1000 μ F Replaceable parts

