♦ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ♦

1409 Series

Capacitance Standard
Operation Manual

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1409 im/April 2010

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

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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.

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.

Contents

Figures and Tables

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 <±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 Standard

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	Adjustment accuracy	Temperature coefficient (ppm/°C)	Dissipation (typical)	Max voltage† (V)	Terminals	Capacitor type
1 nF	1409-F	±0.02%	+20	0.0003	500	2 bp's + gnd	Silvered mica hermetically sealed
10 nF	1409-L	±0.02%	+20	0.0003	500		
100 nF	1409-T	±0.02%	+20	0.0003	500		
1 µF	1409-Y	±0.02%	+20	0.0003	500		

** Peak frequency: 10 kHz*

*** Calibrated at "series model" setup*

† 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 ≥100µF, where f = frequency (in Hz).

Stability:
< 0.01% cahange per year

Calibration conditions:
2-terminal and 3-terminal capacitance values are given
The calibrated value is the capacitance added when the standard is plugged into binding posts
At 30 Vac, 1 kHz, 23°C, <80% RH, Traceable to SI

Operating temperature:
10°C to 50°C

Series inductance:
10 nF - 1 µF: Typically < 0.06 µH

Series resistance:
10 nF - 0.1 µF: 0.02 Ω
1 µF: 0.03 Ω

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

Approximate terminal capacitance:
From H terminal to case (G): 12 to 50 pF
From L terminal to case (G): 300 to 1300 pF

Mechanical
1409-F/L/T:
3.25" x 5.63" x 2.69" (8.3 x 14.3 x 6.9 cm)
2.25 lbs (1.1 kg)
1409-Y:
3.25" x 4" x 29" (8.3 x 10.2 x 5.1 cm)
1.25 lbs (0.6 kg)

Frequency characteristics:

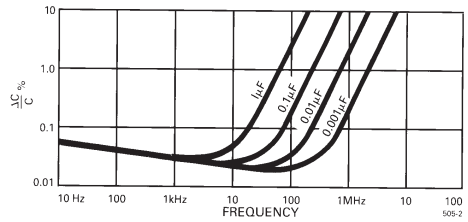

Figure 2-1: Change in capacitance as a function of frequency

Dissipation characteristics

See figure 2-2 and table above.

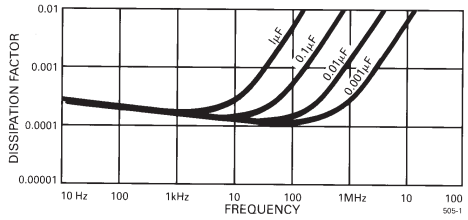

Figure 2-2: Dissipation factor as a function of frequency

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.
formerly manufactured by
GenRad

Westbury, NY 11590
• (516) 334-5959 •
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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

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

Figure 3-1: 1409 capacitor standard
Figure 3-2:

3.3 Environmental Conditions

3.3.1 Operating Temperature

For optimal accuracy, 1409 models should be used in an environment of 23°C ±5°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 ±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.