♦ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ♦

1482 Series

Primary Standard Inductor
User and Service Manual

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1482 im/October 2021

IET LABS, INC.
www.ietlabs.com
Email: info@ietlabs.com
TEL: (516) 334-5959 • FAX: (516) 334-5988

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

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

Chapter 1

INTRODUCTION

1.1 Introduction

The 1482 is an accurate, highly stable standard of self-inductance for use as a low frequency reference or working standard in the laboratory.

Records extending over 40 years, including those of inductors that traveled to national laboratories in several countries for calibration, show long-term stability well within ±0.01%., typically <10 ppm/year.

Each inductor is a uniformly wound toroid on a ceramic core. It has a negligible external magnetic field and hence essentially no pickup from external fields.

The inductor is resiliently supported in a mixture of ground cork and silica gel, after which the whole assembly is cast with a potting compound into a cubical aluminum case.

Values of 500 µH and above have three terminals, 2 for inductor leads and the third connected to the case, to provide either a 2 or 3 terminal standard. See Figure 1-1.

Inductors with less than 500 µH inductance values have three additional terminals to allow for switching between a short circuit and the inductance value which minimizes connection errors.

This allows the user to perform short compensation without disconnecting leads from the inductor. A ground strap is moved to the L_O terminal when short compensation is performed and back to L for measurement of the inductance.

When the same connections are used in both measurements, the inductance value is independent of the external lead inductance even for values much less than 200 µH. The calibrated value of the inductor is $L - L_O$. See Figure 1-2

Figure 1-1

Model 1482 500 µH and above Precision Inductor

Figure 1-2

Model 1482 <500 µH Precision Inductor

Chapter 2

SPECIFICATIONS

For convenience to the user, the pertinent specifications are given in an **LABEL** affixed to the case of the instrument. Figure 2.1 shows a typical example.

SPECIFICATIONS

Inductance Range: See table

Accuracy of Adjustment: Adjustment is performed at one specific frequency, see table for accuracy and adjustment frequency.

Calibration: A certificate of calibration is provided with each unit, giving measured values of inductance at 100, 200, 400, 1000 Hz and 10 kHz(for values < 2 mH), with test conditions, temperature and method of measurement specified.

These values are typically obtained by comparison, to primary 1482s whose absolute values are traceable to an SI. Measurement uncertainties are typically better than ±(0.02%) at all frequencies.

Measurement uncertainties are listed on the calibration certificate.

Stability: Inductance change is less than ±0.01% per year.

DC Resistance: See table for typical values. A measured value of resistance at a specified temperature is given on the certificate of calibration.

Low-Frequency Storage Factor Q:

See table for typical values of Q at 100 Hz (essentially from dc resistance). An individual value of Q is given on each certificate of calibration.

Temperature Coefficient of Inductance: Approximately 30 ppm/°C. Small temperature corrections may be computed from resistance changes.

A 1% increase in resistance, produced by temperature increase of 2.54°C corresponds to 0.0076% increase in inductance.

Resonant Frequency: See table for representative values. A measured value is given on the certificate of calibration. Effective series inductance increases with frequency and this is detailed in GR Experimenter Nov. 1952.

Typically a 1% increase in inductance can be expected if used at 1/10th of resonant frequency.

Maximum Input Power: For a rise of 20°C, 3 W; for precise work, a rise of 1.5°C, 200 mW. See table for corresponding current limits.

Terminals: 5-way gold-plated, tellurium-copper binding posts that feature low resistance. Terminals have standard ¾-in spacing with removable gold-plated ground strap.

Dimensions: 16.6 cm H x 16.6 cm W x 20.4 cm D

(6.5" H x 6.5" W x 8" D)

Weight: 5.3 kg (11.5 lb) net, 6 kg (13 lb) shipping

SPECIFICATIONS CONTINUED

Description	Nominal Inductance	Adjustment Accuracy (%)	Adjustment Frequency (kHz)	*Resonant Frequency (kHz)	*dc Resistance (Ω)	*Q at 100 Hz	mA rms for: 200 mW	3 W
1482-AAA	1 µH	±5%	10	22,500	0.006	0.15	5000	16000
1482-AA	10 µH	±1%	10	7500	0.03	0.30	2500	9000
1482-A	50 µH	±0.5	10	3100	0.039	0.85	2260	8770
1482-B	100 µH	±0.25	10	2250	0.083	0.76	1550	6010
1482-C	200 µH	±0.25	10	1400	0.15	0.84	1150	4470
1482-D	500 µH	±0.1	1	960	0.38	0.83	725	2810
1482-E	1 mH	±0.1	1	800	0.84	0.75	490	1890
1482-F	2 mH	±0.1	1	580	1.52	0.83	360	1400
1482-G	5 mH	±0.1	1	320	3.8	0.83	230	890
1482-H	10 mH	±0.1	1	220	8.2	0.77	156	600
1482-J	20 mH	±0.1	1	145	33.5	0.87	117	450
1482-K	50 mH	±0.1	0.1	84	36.8	0.85	74	280
1482-L	100 mH	±0.1	0.1	71	81	0.78	50	192
1482-M	200 mH	±0.1	0.1	39.0	109	1.15	43	166
1482-N	500 mH	±0.1	0.1	24.5	280	1.12	27	103
1482-P	1 H	±0.1	0.1	14.6	616	1.02	18	70
1482-Q	2 H	±0.1	0.1	10.6	1125	1.12	13.3	52
1482-R	5 H	±0.1	0.1	6.8	2920	1.08	8.3	32
1482-T	10 H	±0.1	0.1	4.9	6400	0.98	5.6	22

*Typical values. Actual values given on certificate

ORDERING INFORMATION

1482-9699 1482-AAA Standard Inductor, 1 µH
1482-9700 1482-AA Standard Inductor, 10 µH
1482-9701 1482-A Standard Inductor, 50 µH
1482-9702 1482-B Standard Inductor, 100 µH
1482-9703 1482-C Standard Inductor, 200 µH
1482-9704 1482-D Standard Inductor, 500 µH
1482-9705 1482-E Standard Inductor, 1 mH
1482-9706 1482-F Standard Inductor, 2 mH
1482-9707 1482-G Standard Inductor, 5 mH
1482-9708 1482-H Standard Inductor, 10 mH
1482-9710 1482-J Standard Inductor, 20 mH
1482-9711 1482-K Standard Inductor, 50 mH
1482-9712 1482-L Standard Inductor, 100 mH
1482-9713 1482-M Standard Inductor, 200 mH
1482-9714 1482-N Standard Inductor, 500 mH
1482-9716 1482-P Standard Inductor, 1 H
1482-9717 1482-Q Standard Inductor, 2 H
1482-9718 1482-R Standard Inductor, 5 H
1482-9720 1482-T Standard Inductor, 10 H

100 mH STANDARD TOROIDAL INDUCTOR

Model 1482-L

ACCREDITED

Adjustment Accuracy: ±0.1% at 100 Hz.
Temperature Coefficient of Inductance: Approx. 30 ppm/°C; temperature correction may be computed from dc resistance changes: **2.54°C** produces **1%** change in resistance produces **76 ppm** change in inductance.
Temperature Coefficient of Resistance: 3930 ppm/°C.
Stability: Inductance change <±0.01%/year.
Maximum Input: 3 W: 192 mArms for 20°C rise;
200 mW: 50 mArms for 1.5°C rise. **Use low power to minimize tempco. effect.**
Test Conditions: SERIES model; at 23°C.
Calibration: See separate **1482 Method of Calibration** label on this unit or with certificate.

Date		Units	5-Apr-07	22-Apr-08	30-Mar-09	4-Jun-10	11-Oct-18
100 Hz	L	mH	100.022	100.007	100.013	99.994	99.990
	Q		0.745	0.748	0.751	0.738	0.734
200 Hz	L	mH	100.019	100.005	100.011	99.989	99.985
	Q		1.49	1.50	1.50	1.48	1.47
400 Hz	L	mH	100.018	100.016	100.010	99.986	99.982
	Q		2.98	2.99	3.00	2.95	2.94
1 kHz	L	mH	100.031	100.018	100.023	100.001	99.997
	Q		7.45	7.48	7.50	7.37	7.34
10 kHz	L	mH	102.234	N/A	N/A	102.201	102.220
	Q		71.56	N/A	N/A	70.95	70.68
dc Resistance		Ω	84.3	84.0	83.6	85.3	85.6
Resonant Freq.		kHz	68.0	67.1	70.6	67.9	*
Temperature		°C	23.3 °C	23.0 °C	23.3 °C	23.2 °C	23.2 °C
Recommended Due			05-Apr-08				
By			RDG	RDG	MJT	RDG	FB

Traceable to SI
* No change in this parameter. Use previous measurement.

SN: C1-18311594

Observe all safety rules when working with high voltages or line voltages. Connect the shield to earth ground in order to maintain the case at a safe voltage. Whenever hazardous voltages (>45 V) are used, take all measures to avoid accidental contact with any live components: a) Use maximum insulation and minimize the use of bare conductors. b) Remove power when adjusting the capacitor. c) Post warning signs and keep personnel safely away.

IET LABS, INC.
Formerly made by
GenRad

• Long Island, NY • Email: info@ietlabs.com
• Tel: (516) 334-5959 • **www.ietlabs.com**

1482-L lbl/p11/100 mH/90%/02-28-13

Figure 2-1. Typical Operating Guide Affixed to 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.

An **Label** is attached to the case of the instrument to provide ready reference to specifications and calibration history.

3.2 Connection

3.2.1 General Considerations

There are different measurement methods depending upon if the 1482 is 3 terminal or 6 terminal. Each is described in the sections below.

The 1482 Standard Inductors use Litz wire. The Litz wire is wound in duplex on a steatite core. The duplex winding minimizes pick-up from external electromagnetic fields and the inductor produces no external magnetic field.

The cores are then potted in a box containing ground cork and desiccant to provide cushioning and effectively “float” the inductor to improve stability. The core does “float” however it should not move in the cork. If movement is detected this generally causes the inductance to be unstable.

Once potted, humidity has little affect on the inductor.

3.2.2 Direct Measurement -3 Terminal

The 1482 Inductor can be directly measured on the Digibridge or other LCR meter. A combination of the 1689-9602 BNC to BNC cable, two BNC-T adapters and Pomona 1894 adaptors are used for connection.

Open and Short compensation should be performed on the LCR Meter or Digibridge per manufacturer instructions.

Spacing should be maintained when performing open compensation.

To minimize noise the high leads are connected to the low terminal of the 1482 and the low terminals to the high terminal of the 1482.

The shorting link is normally connected to the Low terminal during measurements which is how it is calibrated during manufacturing.

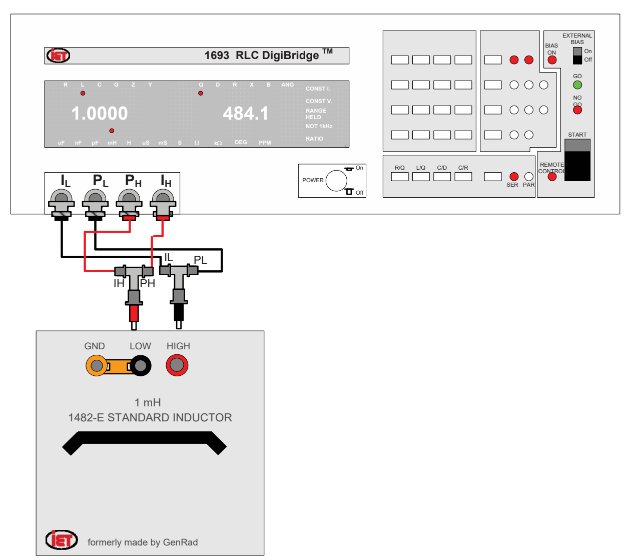

Figure 3-1

The inductance L can then be directly measured and compared with the calibrated value.

3.2.3 Direct Measurement -6 Terminal

Inductors with less than 500 µH inductance values have three additional terminals to allow for switching between a short circuit and the inductance value which minimizes connection errors. These are referred to as 6 terminal inductors.

The 1482 Inductor can be directly measured on the Digibridge or other LCR meter. A combination of the 1689-9602 BNC to BNC cable, two BNC-T adapters and Pomona 1894 adaptors are used for connection.

Other connections can also be used.

Open and Short compensation should be performed on the LCR Meter or Digibridge per manufacturer instructions.

Spacing should be maintained when performing open compensation.

To minimize noise the high leads are connected to the low terminal of the 1482 and the low terminals to the high terminal of the 1482.

For an inductor with 6 binding posts, the LCR meter is connected to the pair of binding posts at the top of the panel. See Figure 3-2

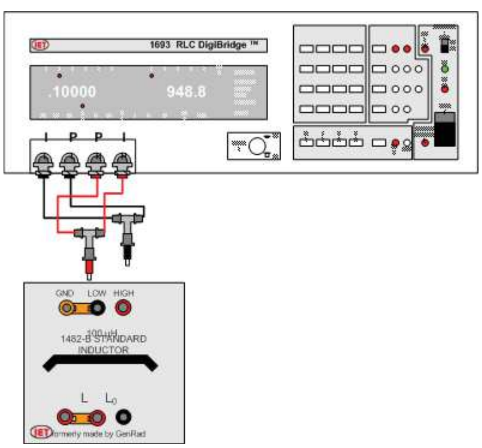

Figure 3-2

The 3 additional binding posts at the bottom of the front panel, allows the user to perform short compensation without disconnecting leads from the inductor.

A shorting link is moved to the L_O terminal when short compensation is performed and back to L for measurement of the inductance.

This provides a simple method to measure the calibrated inductance value of the 1482.

It is recommended however to measure both L and L_O by moving the shorting link appropriately, rather than performing a short compensation when the shorting link is in the L_O position.

The calibrated value of the inductor is then L - L_O .

This is the technique used by IET Labs.

When the same connections are used in both measurements, and only the shorting link is moved the inductance value is independent of the external lead inductance even for values much less than 200 µH.

See GenRad Experimenters October 1960 and November 1952 at www.ietlabs.com for more information

3.3 Frequency Response

Care should be taken to only use the inductor at frequencies significantly less than the resonant frequency.

The inductance increases as resonance is approached. Typically a 1% increase in inductance can be expected if used at 1/10th of resonant frequency.

Cable capacitance also reduces the resonant frequency. This can result in variations especially for 10 H at 1 kHz.

The change in inductance with frequency can be determined by the formula:

$$\Delta L = L_2 - L_1 = \frac{(f_2{}^2 - f_1{}^2)}{(f_r{}^2 - f_2{}^2)}) * L_1$$

where
f_r = resonant frequency

See GenRad Experimenter August 1959 and November 1952 at www.ietlabs.com for more information

3.4 Maximum Input Power

For metrology applications power should be kept less than 200 mW which will cause less than a 1.5°C increase in temperature of the windings in the coil. This can still result in an increase in inductance of 45 ppm.

The input power should be limited to 3 watts, which produces a 20°C increase in temperature of the windings in the coil.

3.5 Environmental Conditions

For optimal accuracy, the inductor should be used in an environment of 23°C. It should be allowed to stabilize at that temperature for more than 48 hours after any significant temperature variation.

Temperature Coefficient of Inductance should be applied when using the 1482 at other temperatures.

Humidity should be maintained at laboratory conditions however the 1482 is effectively devoid of ambient humidity variations.

3.6 Cleaning

The 1482 Inductors are delivered with 5 way gold plated binding posts and gold plated shorting links.

The binding posts and shorting links should be cleaned before use with denatured alcohol.

Chapter 4

MAINTENANCE

4.1 Verification of Performance

4.1.1 Calibration Interval

The **1482** should be verified for performance at a calibration interval of twelve (12) months.

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

IET Labs has significant calibration history on the 1482 which has shown calibration intervals can be significantly longer than 12 months.

4.1.2 General Considerations

It is important, whenever testing the **1482 Standard Inductor**, to be very aware of the capabilities and limitations of the test instruments used.

Typically inductance calibration can be performed using transfer techniques.

The IET Labs 1693 Digibridge can also be used for direct as well as transfer measurements.

Consult IET Labs. for calibration

4.2 Replaceable Parts List

Table 4.2: Replacement List

Model Ref	IET Pt No	Description
1	BP-1000-RD	Binding Post, Red
2	BP-1000-BK	Binding Post, Black
3	BP-1000-GN	Binding Post, Green
4	1482-LNK	Shorting Link, Gold Plated

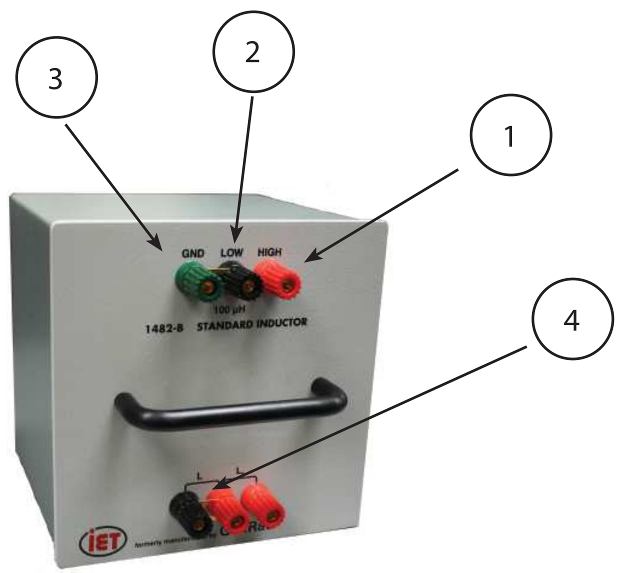

Figure 4-2. 1482 Replaceable Parts