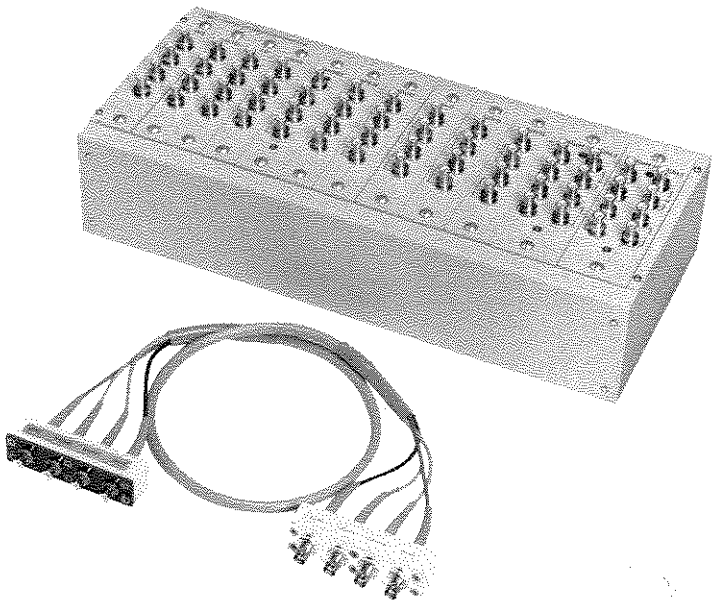
OPERATING NOTE

16074A

CALIBRATION R-L STANDARD



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HP 16074A
Calibration R-L Standard

Operating Note

MANUAL IDENTIFICATION

Model Number: HP 16074A
Date Printed: May 1986
Part Number: 16074-90000

This supplement contains information for correcting manual errors and for adapting the manual to newer instruments that contains improvements or modifications not documented in the existing manual.

To use this supplement
1. Make all ERRATA corrections
2. Make all appropriate serial-number-related changes listed below

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES
All	▸ Change 1
All	▸ Change 2
All	▸ Change 3

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES

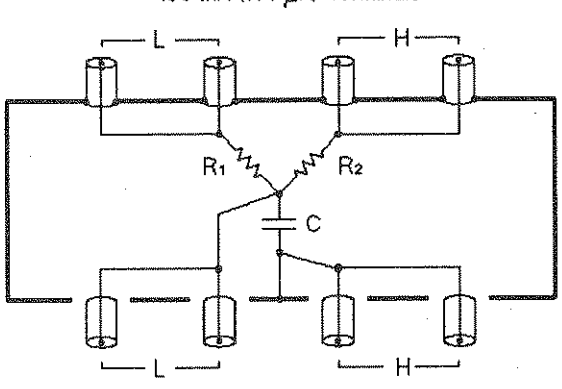
▸ New Item

Change 1

Page 1, Section 5 Quasi-Inductance Standards

Change section 5 as follows:

The HP 16074A's quasi-inductance standard consists of two resistors and a capacitor, and it acts as an inductor when it is measured with HP four-terminal pair LCR meters. Figure 1 shows the quasi-inductance standard's structure and an equivalent impedance when the quasi-inductance Standard's 100 μH (or 100 mH) terminals are connected to an HP LCR meter.



$Z = Rs + j\omega Ls$

Rs : $R_1 + R_2$
Ls : CR_1R_2
j : Imaginaly Unit
ω : Angular Frequency

Figure 1. Quasi-Inductance Standard Structure

NOTE
Manual change supplement are revised as often as necessary to keep manuals as current and accurate as possible. Hewlett-Packard recommends that you periodically request the latest edition of this supplement. Free copies are available from all HP offices. When requesting copies, quote the manual identification information from your supplement, or the model number and print date from the title page of the manual.

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Table 1 shows the typical values for the resistors and the capacitor in Figure 1.

Table 1. Typical Values for Quasi-Inductance Standards

Description	R1	R2	C
100 mH	1 kΩ	1 kΩ	100 nF
100 μH	316 Ω	316 Ω	1 nF

The quasi-inductance standard's equivalent inductance should be measured by its user before it is used to confirm LCR meter's inductance measurement operation. The measurement procedure is as follows:

1. Measure the two resistors of the quasi-inductance standard using a four terminal connection DC resistance meter, and record these two resistance values as R1 and R2.

   * R1 is the resistance between the 100 mH (or 100 μH) L terminal and the (C-CAL) L terminal.

   * R2 is the resistance between the 100 mH (or 100 μH) H terminal and the (C-CAL) L terminal.

2. Measure the capacitance of the quasi-inductance standard using a four-terminal pair LCR meter, and record the capacitance value as C.

   * Connect the (C-CAL) terminal to the LCR meter to measure the capacitance.

3. Calculate the equivalent inductance according to the following equation.

   Equivalent Inductance = (C - 7 pF) x R1 x R2

   * 7 pF is the correction capacitance for the BNC connectors.

Change 2

Page 1, Section 7 Calibration Data

Change section 7 as follows:

The calibration data for each resistance module of the HP 16074A is given on the calibration data sheet provided with the HP 16074A. Table 2 shows the calibrated parameters and their calibration uncertainties.

The HP 16074A should be calibrated at the facility which satisfies the calibration uncertainties given in Table 2. Hewlett-Packard's calibration laboratories satisfy all of these calibration uncertainties.

Table 2. Calibrated Parameters

Module Description	Calibrated Parameter	Calibration Uncertainty
0.1 Ω [1]	R_{DC} Ls	1.0% 1 nH
1 Ω [1]	R_{DC} Ls	0.1% 0.3 nH
10 Ω [1]	R_{DC} Ls	0.03% 1 nH
100 Ω [2]	R_{DC} Ls G_{DC} Cp	0.03% 20 nH 0.03% 2 pF
1 kΩ [2]	R_{DC} Cp	0.03% 0.2 pF
10 kΩ [2]	R_{DC} Cp	0.03% 0.1 pF
100 kΩ [2]	R_{DC} Cp	0.03% 0.05 pF

R_{DC}: Resistance at DC
G_{DC}: Conductance at DC
Ls: Equivalent Series Inductance at 1 MHz
Cp: Equivalent Parallel Capacitance at 1 MHz

1: Calibrated values are relative to the HP 16074A's 0 Ω module.

2: Calibrated values are relative to the HP 16074A's SHORT module.

Change 3

Page 2, Table 1. Specifications

Delete the Calibration Accuracy column in Table 1.

1. INTRODUCTION

This operating note provides the information necessary to use the Model 16074A calibration R-L standard, shown pictorially on the front cover. Included is a description of the 16074A, its specifications, the internal construction of each standard, and other basic information. Specifications are listed in Table 1.

2. DESCRIPTION

The 16074A is specially designed for calibration and performance testing of HP's various four-terminal-pair type LCR meters. It consists of eight resistance standards--0Ω, 0.1Ω, 1Ω, 10Ω, 100Ω, 1kΩ, 10kΩ, and 100kΩ--two quasi-inductance standards--100μH and 100mH--and two terminations--OPEN and SHORT. The state-of-the-art four-terminal-pair configuration of the 16074A insures high accuracy at frequencies up to 13MHz. The 0Ω through 10Ω standards contain thin film resistors that have minimal residual reactance and stray capacitance; the 100Ω through 100kΩ standards are each shielded to reduce the effects of noise.

3. OPEN AND SHORT TERMINATIONS

The 16074A's OPEN and SHORT terminations facilitate optimum open and short zero offset compensation of the test instrument to insure accurate measurements. Before calibrating the test instrument with any capacitance, inductance, or resistance standards, open and short zero offset compensation must be performed. For details, refer to the test instrument's Operation Manual.

4. RESISTANCE STANDARDS

The nominal value of each resistance standard is specified at DC and is extended up to 13MHz. The high frequency characteristics are based on the appropriate series or parallel equivalent circuit calculations. The 100Ω, 1kΩ, 10kΩ, and 100kΩ standards are designed for resistance measurement calibration; thus, nominal value accuracy is ±0.1%. The 0.1Ω, 1Ω, and 10Ω standards, however, are designed for phase accuracy calibration. They have extremely low residual reactance, and are calibrated for their phase accuracy rather than resistance accuracy. Basic accuracy is, thus, ±10%.

Note

The SHORT termination and the 0Ω resistance standard should not be used interchangeably. The SHORT termination is an absolute short, intended for short zero offset compensation in capacitance, inductance, and resistance measurements calibration. The 0Ω standard, however, is not an absolute 0Ω. It, like the 0.1Ω, 1Ω, and 10Ω standards, is intended for phase measurement calibration only. Before calibrating the test instrument's phase measurement accuracy, perform zero offset compensation using the 0Ω standard and OPEN termination. In all other cases, use the SHORT and OPEN terminations.

5. QUASI-INDUCTANCE STANDARDS

Because of the inherent parasitic impedances (coil resistance and distributed capacitance) of inductors, it is not possible to build an inductance standard usable in the RF region. Therefore, each of the two quasi-inductance standards in the 16074A is constructed using two resistors and one capacitor, offering equivalent inductances of 100μH and 100mH. The internal construction is illustrated in Table 2 and the equivalent circuits are shown in Table 1.

6. CONNECTING THE 16074A

The 16074A can be connected to the test instrument in one of two ways : (1) directly to the instrument's UNKNOWN terminals or (2) via the furnished four-terminal-pair cable (P/N : 16074-61600). Either connection method can be used without affecting the measurement accuracy of the instrument. SHORT and OPEN zero offset compensation must be performed, though, to cancel the residual inductance, residual resistance, and stray capacitance of the cable. Also, when the cable is used and the test signal frequency is higher than 1MHz, the test instrument must be set to the appropriate cable length. Refer to the test instrument's Operation and Service Manual for details.

7. CALIBRATION DATA

Calibration data for each resistance standard at DC and each quasi-inductance standard at several test frequencies are given on the calibration data sheet included in the 16074A.

8. CALIBRATION CYCLE

The recommended calibration cycle of the 16074A is once a year.

9. REPAIR

The 16074A is not field repairable. If any of the standards or terminations are damaged or if a significant nominal value change is observed, return the unit to Hewlett-Packard for service. For complete information on service or calibration, contact the nearest Hewlett-Packard office.

Table-1. Specifications.

Contents:

Resistors --- 0Ω, 0.1Ω, 1Ω, 10Ω, 100Ω, 1kΩ, 10kΩ and 100kΩ

Terminations --- open and short

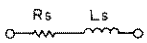
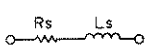
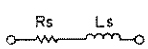
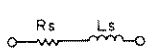
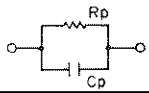
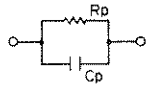
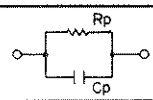
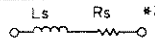
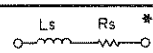
Inductors --- 100μH and 100mH

Useable frequency: DC to 13MHz

Accessory furnished:
1m cable --- HP P/N: 16074-61600

Environmental temperature:
23°C ± 5°C

Characteristics:

Nominal Value	Equivalent Circuit	Parameter Main/Sub	Calibration Accuracy	Typical Frequency Characteristic	Typical Temperature Coefficient
0.1Ω ± 10% *1		Rs	±0.1% at DC	$\pm\frac{f^2MHz}{1000}\%$	±100 PPM
		Ls	0 ± 1nH up to 1MHz	———	———
1Ω ± 10% *1		Rs	±0.1% at DC	$\pm\frac{f^2MHz}{1000}\%$	-60 PPM
		Ls	±0.2nH at 1MHz	———	———
10Ω ± 10% *1		Rs	±0.03% at DC	$\pm\frac{f^2MHz}{1000}\%$	-60 PPM
		Ls	0 ± 1nH up to 10MHz	———	———
100Ω ± 0.1%		Rs	±0.03% at DC	$\pm\frac{f^2MHz}{1000}\%$	±10 PPM
		Ls	±20nH at 1MHz	———	———
1kΩ ± 0.1%		Rp	±0.03% at DC	$\pm\frac{f^2MHz}{1000}\%$	±10 PPM
		Cp	±0.2pF at 1MHz	———	———
10kΩ ± 0.1%		Rp	±0.03% at DC	$\pm\frac{2f^2MHz}{100}\%$	±10 PPM
		Cp	±0.2pF at 1MHz	———	———
100kΩ ± 0.1%		Rp	±0.03% at DC	$\pm 2f^2MHz\%$	±10 PPM
		Cp	±0.2pF at 1MHz	———	———
100mH + 2kΩ	 Ls = R1 · R2 · C(H)	Ls	100nF measurement error + 0.1%	$\pm 10f^2MHz\%$	±10 PPM
		Rs	±0.03% at DC	±ωLD *4	———
100μH + 632Ω	 Ls = R1 · R2 · (C - 7.1pF)(H) *3	Ls	1000pF measurement error + 0.2%	$\pm 4(\frac{fMHz}{10})^2\%$	±10 PPM
		Rs	±0.03% at DC	±ωLD *4	———

*1 The calibration values of 0.1Ω thru 10Ω resistors are defined as the difference (respectively resistance and residual reactance) on the basis of 0Ω.

*2 Rs is equal to R1 plus R2.

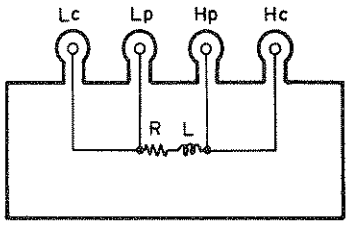
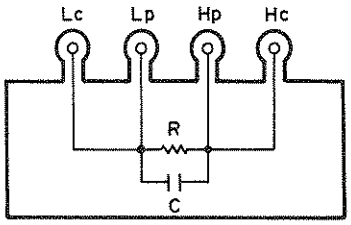
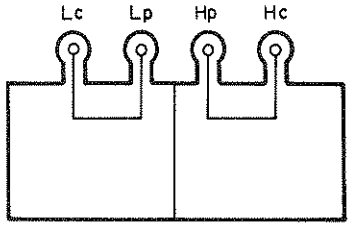
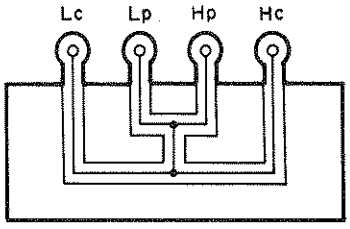
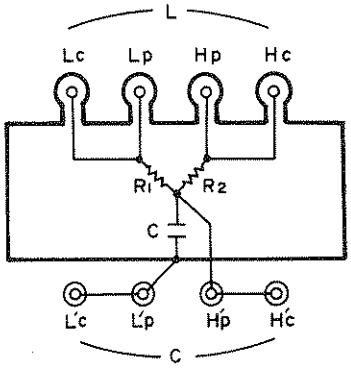
*3 This equation includes a compensation of the stray capacitance associated with the BNC terminals.

*4 D is the dissipation value of the capacitor at the respective setting frequencies.

Dimensions:
423(W) x 120(H) x 186(W) mm

Weight:
Approximately 4.4kg

Table 2. Construction of Each Standard

Standard	Use	Construction
0Ω	Termination for zero offset adjustment (short: cancellation of residual inductances and resistances) prior doing frequency phase accuracy check.	
0.1Ω 1Ω 10Ω	Frequency phase accuracy check.	
100Ω		
1kΩ 10kΩ 100kΩ	Resistance measurement accuracy check.	
Open Termination	Termination for zero offset adjustment (open: cancellation of stray capacitance) to perform accurate measurements.	
Short Termination	Termination for zero offset adjustment (short: cancellation of residual inductances and resistances) to perform accurate measurements.	
100μH 100mH	Inductance measurement accuracy check.	

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