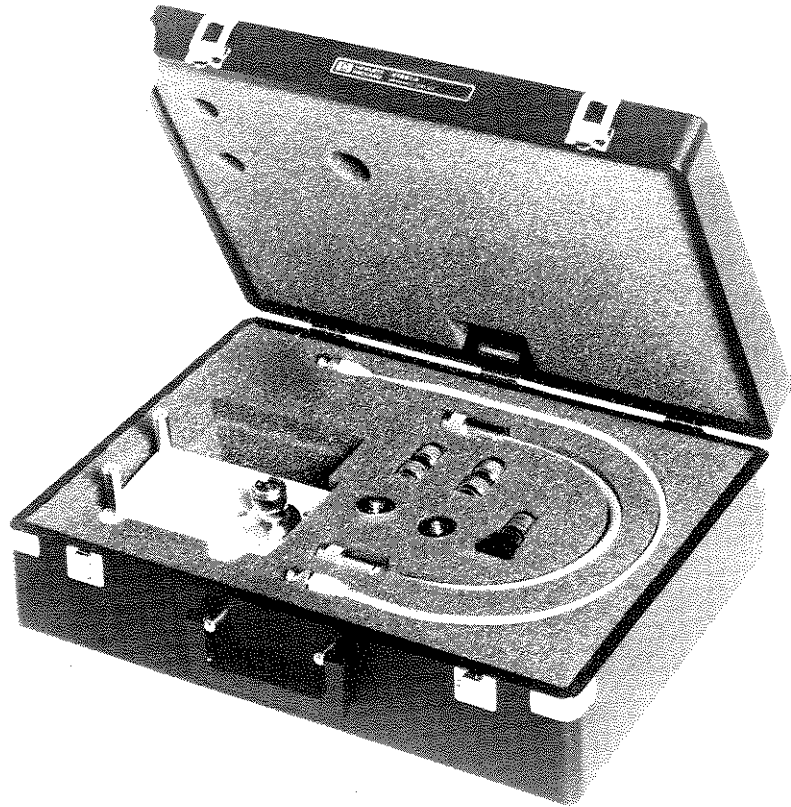


# 41951A

## IMPEDANCE TEST KIT

### for HP 4195A



NOV. 1987

 **HEWLETT  
PACKARD**

## **WARRANTY AND ASSISTANCE**

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

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# MANUAL CHANGES

## HP 41951A

### Impedance Test Kit for HP 4195A

#### MANUAL IDENTIFICATION

Model Number: HP 41951A  
Date Printed: November, 1987  
Part Number: 41951-90000

This supplement contains information for correcting manual errors and for adapting the manual to newer instruments that contain 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

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES
ALL	1

SERIAL PREFIX OR NUMBER      MAKE MANUAL CHANGES

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES

▶ New Item

#### ERRATA

- ▶ Page 1-3, Table 1-2. Contents

Change the part number of item 1, Impedance Test Adapter, to 41951-61001.

- ▶ Page 1-6, Figure 1-3. Impedance Measurement Accuracy

Change the chart's inductance axis 10fH and 100fH scale labels to 10pH and 100pH, respectively.

#### NOTE

Manual change supplements 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.

**CHANGE 1**

Page 6-6, Table 6-3. Replaceable Parts

Change item 5 as follows.

Reference Designator	HP Part Number	Qty.	Description
5	1250-1811	3	N(f)-SMA(f) Adapter (with NUT)
	2190-0054	3	Washer



OPERATION NOTE

**MODEL 41951A**  
**IMPEDANCE TEST KIT**  
**for HP 4195A**

**SERIAL NUMBERS**

This operation note applies directly to 41951As with 2746J- prefixed serial numbers.

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9-1, TAKAKURA-CHO, HACHIOJI-SHI, TOKYO, JAPAN

Manual Part No. 41951-90000  
Microfiche Part No. 41951-90050

Printed: Nov. 1987

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## SECTION 1

## GENERAL INFORMATION

**1-1. INTRODUCTION**

This operation note provides the information necessary to use the HP 41951A Impedance Test Kit with the HP 4195A Network/Spectrum Analyzer. Refer to the 4195A's Operation Manual for specific 4195A operating procedures.

**1-2. DESCRIPTION**

The 41951A Impedance Test Kit is an accessory for the 4195A. Figure 1-1 shows the contents of the HP 41951A.

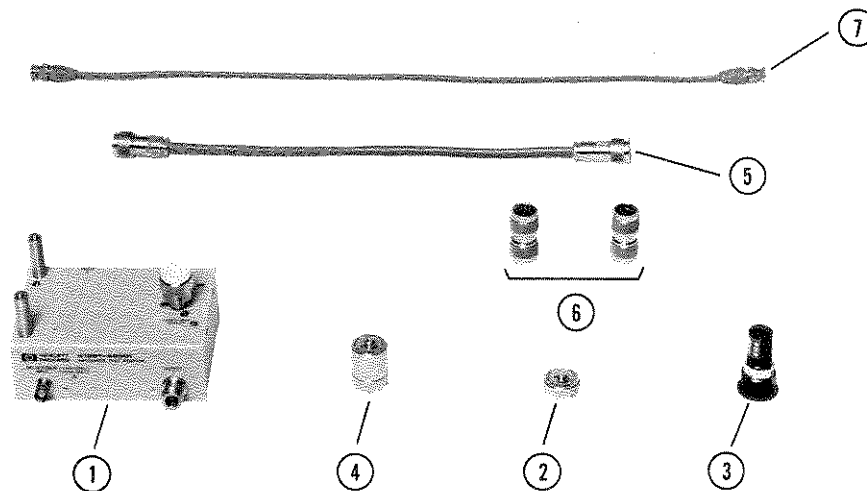


Figure 1-1. Contents of HP 41951A

**1-3. SPECIFICATIONS**

The specifications for the 41951A Impedance Test Kit is listed in Table 1-1. The specifications are performance standards or limits. The 41951A meets all of the specifications listed in Table 1-1 when shipped from the factory.

**1-4. SAFETY CONSIDERATIONS**

The 41951A Impedance Test Kit conform to the safety requirements for IEC 348, and CSA 556B instruments, and is shipped from the factory in a safe condition. This operation note contains information, **CAUTIONS**, and **WARNINGS** which must be followed by the user to ensure safe operation.

## 1-5. UNITS COVERED BY THIS OPERATION NOTE

Hewlett-Packard uses a two-part, nine character serial number which is stamped on the serial number plate ( see Figure 1-2 ) attached to the inside of the carrying case. The first four digits and a letter are the prefix and the last five digits are the suffix of the serial number. The letter in the serial number identifies the country where the instrument was manufactured. The prefix is same for all identical instruments, it changes only when a change is made to the instrument. The suffix, however, is assigned sequentially and is different for each instrument. This operation note applies to instruments with serial number prefixes listed under **Serial Numbers** on the title page.



Figure 1-2. Serial Number Plate

Units manufactured after this operation note was printed may have a serial number prefix which is not listed on the title page. An unlisted serial number prefix indicates that the instrument may be different from those described in this operation note. Operation notes for new instruments may be accompanied by a yellow Manual Changes supplement page, or have a different part number. This supplement contains "**Change Information**" explaining how to adapt this operation note to newer instruments.

In addition to change information, the supplement may contain information for correcting errors ( Errata ) in previous operation notes. To keep this operation note as current and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Change supplements. The supplement for this operation note is identified by the **Print Date** and **Part Number**, both of which appear on the operation note's title page.

For information concerning the serial number prefixes not listed on the title page or in the Manual Change supplements, contact your nearest Hewlett-Packard Sales office.



**1-6. CONTENTS**

Table 1-2 lists the contents, and includes **No.** which are the same as the designation in Figure 1-1, **Description**, **Qty.** ( Quantity ), and **HP part number**.

Table 1-2. Contents

No.	Description	Qty.	HP Part Number
1	Impedance Test Adapter	1	PN 41951-69001
2	0 $\Omega$ Calibration Standard	1	PN 04191-85300
3	50 $\Omega$ Calibration Standard	1	PN 04191-85301
4	0S Calibration Standard	1	PN 04191-85302
5	N(m)-N(m) Cable	1	PN 41951-61602
6	N(m)-N(m) Adapter	2	PN 1250-0778
7	BNC(m)-BNC(m) Cable	1	PN 8120-1839
	Carrying case	1	PN 41951-60001 <sup>1</sup>

**Note** <sup>1</sup>: The serial number plate is not included in the carrying case.

**1-7. AVAILABLE ACCESSORIES**

For making certain types of measurements and for convenience in connecting samples, five accessories are available. Each is designed to meet the various measurement requirements of a variety of test devices. All accessories are developed with careful consideration to accuracy, reliability, and ease of use. A brief description and a photo of each available accessory are given in Table 1-3.

Table 1-1. Specifications ( 1 of 2 )

**41951A Specifications**

<b>Usable Frequency Range:</b>	100 kHz to 500 MHz
<b>DC Bias Range:</b>	$\pm 40$ V, $\pm 0.5$ A
<b>UNKNOWN Port:</b>	APC-7 Connector
<b>Weight:</b>	Approx. 2.7 kg Approx. 0.55 kg ( Test Adapter only )
<b>Operation Environment:</b>	0°C to 55°C $\leq 95\%$ RH at 40°C
<b>Storage Environment:</b>	-40°C to 70°C

The following specifications apply to the 4195A when used with the 41951A.

<b>Measurement Parameter:</b>	$ Z $ , $ Y $ , $\theta$ , R, X, G, B, L, C, D, $Q(=1/D)$
<b>Test Frequency Range:</b>	100 kHz to 500 MHz
<b>Signal Level at DUT ( nominal ):</b>	-62 dBm to +3 dBm at 50 $\Omega$ load
	Note: Signal level ( at DUT ) is 12 dB lower than 4195A output level.
<b>Output Impedance:</b>	Nominal 50 $\Omega$
<b>DC Bias (supplied from 4195A):</b>	
Voltage Range	-40 V to 40 V
Resolution	10 mV
Accuracy	$\pm( 0.12\%+12 \text{ mV } )$ at 23°C $\pm 5^\circ\text{C}$
Maximum Current	$\pm 20$ mA

Table 1-3. Specifications ( 2 of 2 )

**Measurement Range and Highest Resolution:**

Parameter	Range	Resolution
Z , R, X	30 mΩ to 30 kΩ	10 mΩ
Y , G, B	30 μS to 30 S	10 μS
$\theta$	-180° to 180°	0.01°
L	10 pH to 30 mH	10 pH
C	10 fF to 30 μF	10 fF
D	0.001 to 10	0.0001
Q	0.1 to 1000	0.01

**Measurement Accuracy ( Supplemental Performance Characteristics ):**

Measurement accuracy is specified at the connecting surface of the APC-7 connector, under the following conditions.

- 1) Warm up Time: >30 minutes
- 2) Ambient Temperature: 23°C ±5°C  
at the same temperature at which  
Calibration was performed
- 3) Output Signal Level: 15 dB greater than the Input Range of  
reference port ( the value indicated by  
' RANGE R=' on the 4195A's display )
- 4) Signal Level at DUT: -20 to +3 dBm
- 5) Correction: ON

Figure 1-3 shows the impedance measurement accuracy of HP 4195A when used with the 41951A.

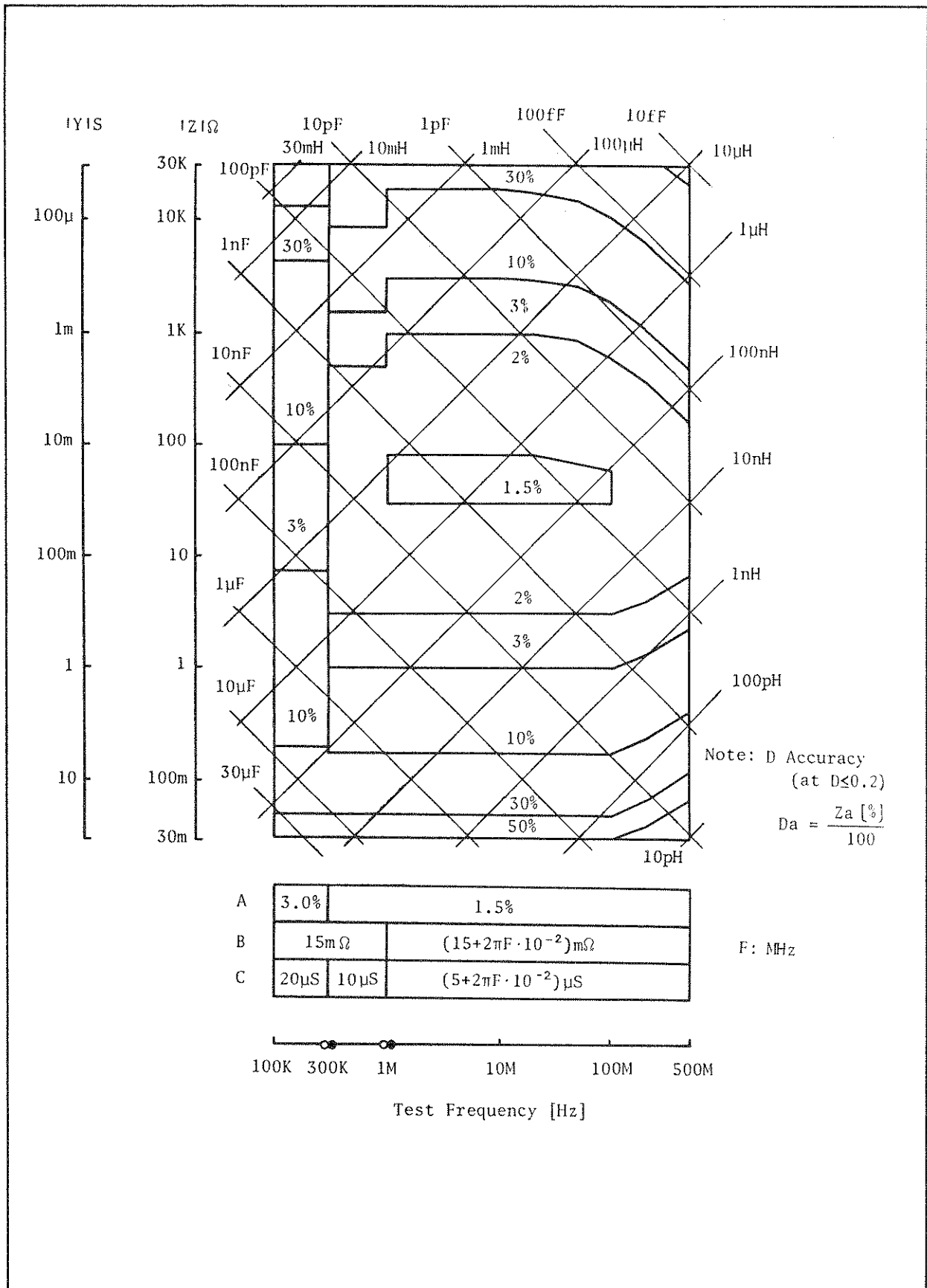
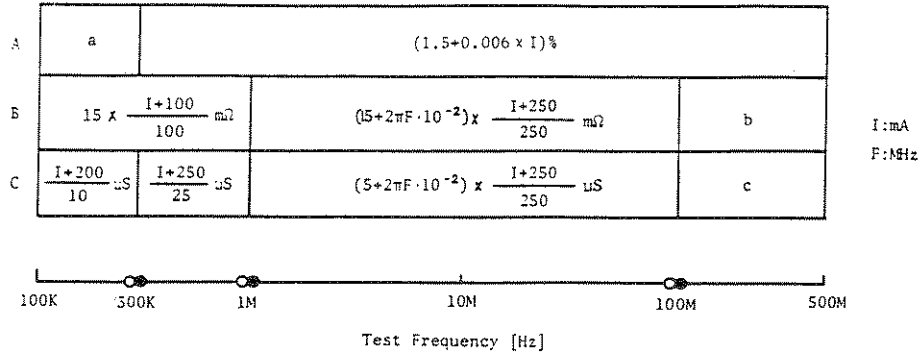


Figure 1-3. Impedance Measurement Accuracy ( 1 of 4 )

- Note: 1. The above data applies to the averaged measurement data (applies when the VIDEO FILTER is on).
2. When the DC bias is used, use the following value of A, B, and C in place of the above value, to calculate the measurement accuracy.



$$a: (3.0+0.006 \times I)\%$$

$$b: (15+2\pi F \cdot 10^{-2}) \times \frac{I+100}{100} \text{ m}\Omega$$

$$c: (5+2\pi F \cdot 10^{-2}) \times \frac{I+100}{100} \mu\text{S}$$

**|Z| -  $\theta$  Accuracy:**

|Z| accuracy  $Z_a = A+(B/|Z_m|+C \times |Z_m|) \times 100 (\%)$

$\theta$  accuracy  $\theta_a = \sin^{-1}(Z_a/100)$

Where |Z<sub>m</sub>| is |Z| measured. A, B and C are obtained from the graph above.

**|Y| -  $\theta$  Accuracy:**

|Y| accuracy  $Y_a = A+(B \times |Y_m|+C/|Y_m|) \times 100 (\%)$

$\theta$  accuracy  $\theta_a = \sin^{-1}(Y_a/100)$

Where |Y<sub>m</sub>| is |Y| measured. A, B and C are obtained from the graph above.

Figure 1-3. Impedance Measurement Accuracy ( 2 of 4 )

**R, X Accuracy ( depends on D ):**

	$D \leq 0.2$	$0.2 < D \leq 5$	$5 < D$
Ra	$\pm X_m \cdot \frac{Z_a(X)}{100} (\Omega)$	$\frac{Z_a(R)}{\cos \theta} (\%)$	$Z_a(R) (\%)$
Xa	$Z_a(X) (\%)$	$\frac{Z_a(X)}{\sin \theta} (\%)$	$\pm R_m \cdot \frac{Z_a(R)}{100} (\Omega)$

D can be calculated as  $R/X$ ,  
 $R/(2 \times \pi \times f \times L_s)$  or  $R \times 2 \times \pi \times f \times C_s$

$\theta$  can be calculated as  $\tan^{-1}(X/R)$ ,  
 $\tan^{-1}(2 \times \pi \times f \times L_s/R)$  or  
 $\tan^{-1}(1/(R \times 2 \times \pi \times f \times C_s))$

$Z_a(R) = A + (B/|R_m| + C \times |R_m|) \times 100 (\%)$

$Z_a(X) = A + (B/|X_m| + C \times |X_m|) \times 100 (\%)$

$R_m$  and  $X_m$  are the measured R and X, respectively. A, B and C are obtained from the preceding graph.

**G, B Accuracy ( depends on D ):**

	$D \leq 0.2$	$0.2 < D \leq 5$	$5 < D$
Ga	$\pm B_m \cdot \frac{Y_a(B)}{100} (S)$	$\frac{Y_a(G)}{\cos \theta} (\%)$	$Y_a(G)$
Ba	$Y_a(B) (\%)$	$\frac{Y_a(B)}{\sin \theta} (\%)$	$\pm G_m \cdot \frac{Y_a(G)}{100} (S)$

D can be calculated as  $G/B$ ,  
 $G/(2 \times \pi \times f \times C_p)$  or  $G \times 2 \times \pi \times f \times L_p$

$\theta$  can be calculated as  $\tan^{-1}(B/G)$ ,  
 $\tan^{-1}(2 \times \pi \times f \times C_p/G)$  or  
 $\tan^{-1}(1/(G \times 2 \times \pi \times f \times L_p))$

$Y_a(G) = A + (B \times |G_m| + C/|G_m|) \times 100 (\%)$

$Y_a(B) = A + (B \times |B_m| + C/|B_m|) \times 100 (\%)$

$G_m$  and  $B_m$  are measured G and B, respectively. A, B and C are obtained from the preceding graph.

Figure 1-3. Impedance Measurement Accuracy ( 3 of 4 )

**D Accuracy:**

	$D \leq 0.2$	$0.2 < D$
Da	Za/100	$(Za/100) \times (1 + D^2)$

Where Za is |Z| accuracy

**L Accuracy ( depends on D ):**

	$D \leq 0.2$	$0.2 < D$
La	La	$La \times (1 + D)$

Where

$$La = A + (B/|Z| + C \times |Z|) \times 100 (\%)$$

Where  $|Z| = 2 \times \pi \times f \times Lm$ , f is frequency in Hz and Lm is measured L. A, B and C are obtained from the preceding graph.

**C Accuracy ( depends on D ):**

	$D \leq 0.2$	$0.2 < D$
Ca	Ca	$Ca \times (1 + D)$

Where

$$Ca = A + (B/|Zc| + C \times |Zc|) \times 100 (\%)$$

Where  $|Zc| = 1/2 \times \pi \times f \times Cm$ , f is frequency in Hz and Cm is the measured C. A, B and C are obtained from the preceding graph.

Figure 1-3. Impedance Measurement Accuracy ( 4 of 4 )

Table 1-3. Available Accessories ( 1 of 2 )

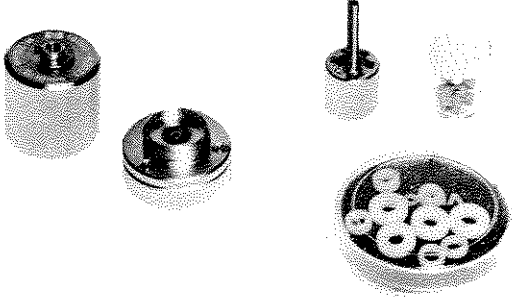
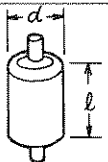
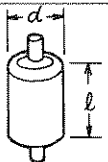
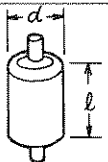
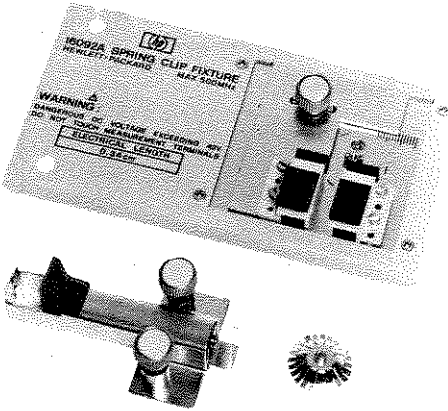
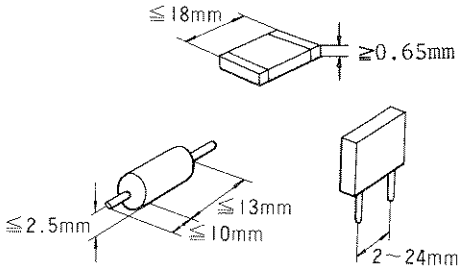
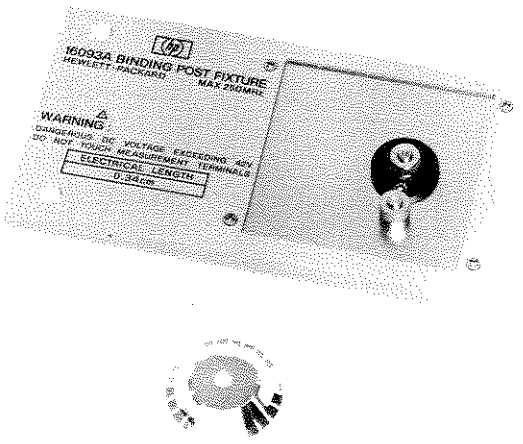
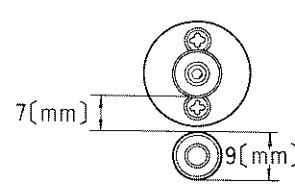
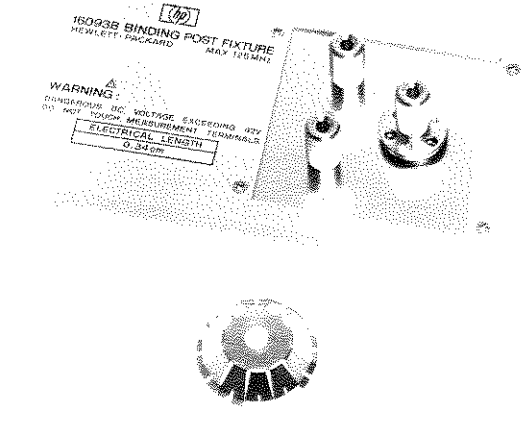
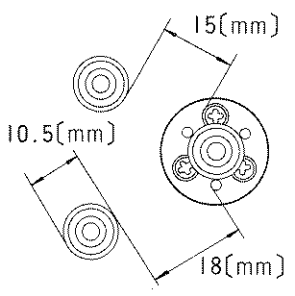
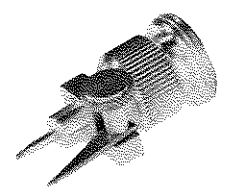
Model	Description																
<p>HP 16091A</p> 	<p>Coaxial Fixtures</p> <p>Test Fixtures ( coaxial termination type ) for holding a piece of sample holders accommodate a cylindrical sample in their respective inner chambers. Two kinds of fixtures fit samples dimensions given below:</p> <table border="1"> <thead> <tr> <th>Sample</th> <th>Fixture</th> <th colspan="2">Max. dimensions</th> </tr> </thead> <tbody> <tr> <td rowspan="2">  </td> <td rowspan="2">04191-85302</td> <td>d</td> <td>7 mm</td> </tr> <tr> <td>ℓ</td> <td>20 mm</td> </tr> <tr> <td rowspan="2"></td> <td rowspan="2">16091-60012</td> <td>d</td> <td>10 mm</td> </tr> <tr> <td>ℓ</td> <td>20 mm</td> </tr> </tbody> </table> <p>Usable frequency range: DC to 1000 MHz. Electrical length: 1.87 cm ( typical ). Maximum applied DC bias voltage: ±40 V.</p> <p>Note: The 16091A fixture of 7 mm inner diameter ( P/N 04191-85302 ) is actually the same as the OS standard termination. Thus, this fixture is not supplied with the 16091A fixture set since the furnished OS termination can be used.</p>	Sample	Fixture	Max. dimensions			04191-85302	d	7 mm	ℓ	20 mm		16091-60012	d	10 mm	ℓ	20 mm
Sample	Fixture	Max. dimensions															
	04191-85302	d	7 mm														
		ℓ	20 mm														
	16091-60012	d	10 mm														
		ℓ	20 mm														
<p>HP 16092A</p> 	<p>Spring Clip Fixture</p> <p>Test fixture for connecting axial and radial lead components, and leadless chip components. The spring clip contacts can be adjusted to the dimensions given below.</p>  <p>A slide gauge provides direct read-out of the length of the test sample. Maximum applicable DC bias is ±150 V/±0.5 A.</p>																



Table 1-3. Accessories Available ( 2 of 2 )

<p>HP 16093A</p>  <p>The image shows the HP 16093A Binding Post Fixture, a rectangular metal plate with a terminal deck on the right side. A warning label is visible on the left side of the plate. Below the main image is a smaller circular inset showing the terminal deck layout.</p>	<p><b>Binding Post Fixture</b></p> <p>A test fixture used when measuring miniature axial and radial lead components. Two binding post terminals at intervals of 7 mm on the terminal deck ensure optimum contact of terminals and the test sample leads.</p>  <p>The diagram shows a circular terminal deck with two binding post terminals. A dimension line indicates a 7 mm interval between the terminals. Another dimension line indicates a 9 mm diameter for the terminal deck.</p> <p>The maximum DC bias that can be applied is <math>\pm 40 \text{ V} / \pm 0.5 \text{ A}</math>.</p>
<p>HP 16093B</p>  <p>The image shows the HP 16093B Binding Post Fixture, a rectangular metal plate with a terminal deck on the right side. A warning label is visible on the left side of the plate. Below the main image is a smaller circular inset showing the terminal deck layout.</p>	<p><b>Binding Post Fixture</b></p> <p>A Test fixture for connecting common axial and radial lead components. Three binding post terminals are located on the terminal deck as shown below.</p>  <p>The diagram shows a circular terminal deck with three binding post terminals. Dimension lines indicate a 15 mm interval between the top two terminals, a 10.5 mm interval between the top and bottom terminals, and an 18 mm diameter for the terminal deck.</p> <p>The maximum DC bias that can be applied is <math>\pm 40 \text{ V} / \pm 0.5 \text{ A}</math>.</p>
<p>HP 16094A</p>  <p>The image shows the HP 16094A Probe Fixture, a cylindrical metal component with a probe needle extending from the tip.</p>	<p><b>Probe Fixture</b></p> <p>Test Fixture for measurement of circuit impedances and components mounted on circuit assemblies. The probe adapter unit can be attached at the tip of an extension line connected to the test port. The probe connector fits APC-7 connector of a coaxial test cable or a flexible air line. Probe needle interval is variable from 1 mm to 15 mm. Electrical length compensation in the instrument must be adjusted for probe cable length.</p> <p>Usable frequency range: DC to 125 MHz.          Electrical length: 2.32 cm ( typical ).          Maximum applied DC bias voltage: <math>\pm 40 \text{ V}</math>.</p>



## SECTION 2

## INSTALLATION

**2-1. INTRODUCTION**

This section provides installation instructions for the HP 41951A Impedance Test Kit. It also includes information on the initial inspection, damage claims, preparation for using the 41951A, packaging, storage, and shipment.

**2-2. INITIAL INSPECTION**

The 41951A Impedance Test Kit meet all of the specifications listed in Table 1-1. Upon receipt, inspect the shipping container for damage. If the shipping container or the cushioning material has been damaged, keep the container and packing material until the contents have been checked for completeness and the test kit has been checked out mechanically and electrically. The contents should be as shown in Figure 1-1. The procedures for checking the general electrical operation are given in Section 4.

If anything is missing, damaged ( scratches, dents, broken connectors, etc. ), or if performance does not meet the verification test limits, notify the nearest HP Sales office ( see the list at the back of this operation note ). The HP Sales Office will immediately arrange for repair or replacement without waiting for a claim settlement.

**2-3. INTERCONNECTIONS**

The interconnection between the 41951A and the 4195A, is achieved by connecting the **Impedance Test Adapter** to the 4195A's **Channel 1** or **2**, using the furnished **Adapters** and **Cables**.

1. Connect two female N-type connectors; **INPUT S** and **OUTPUT R**, to the 4195A's **OUTPUT S1** ( or **S2** ) and **INPUT R1** ( or **R2** ) connectors, using two furnished N(m)-N(m) Adapters, respectively.

**NOTE**

When connecting the **INPUT S** and **OUTPUT R** connectors, do not try to tighten one connector completely, alternately tighten each connector, little by little, until both connectors are tight.

2. Connect the **OUTPUT T** connector to the 4195A's **INPUT T1** ( or **T2** ) connector, using the furnished N(m)-N(m) Cable.
3. If the DC bias supplied from the 4195A is used, connect the **DC SOURCE INPUT** connector to the 4195A's **DC SOURCE OUTPUT** connector using the furnished BNC(m)-BNC(m) Cable.

**NOTE**

If the DC bias supplied from an external DC power supply is used, connect the **DC SOURCE INPUT** connector to the power supply's output terminal. The outer conductor of the **DC SOURCE INPUT** connector is grounded.

**2-4. STORAGE ENVIRONMENT**

The 41951A may be stored or shipped under the following environmental conditions.

Temperature      -40°C to 70°C

The unit must be protected from temperature extremes which can cause condensation.

**2-5. PACKING****Original Packing.**

Containers and packing material identical to those used in factory packaging are available from Hewlett-Packard. If the unit is being returned to Hewlett-Packard for servicing, attach a tag indicating the type of service required, return address, model number and full serial number.

**Other Packing.**

The following general instructions should be used for repacking with commercially available materials:

- a. Wrap the unit in heavy paper or plastic. If shipping to a Hewlett-Packard Sales Office or Service Center, attach a tag indicating the type of service required, return address, model number and the full serial number.
- b. Use a strong shipping container. A double-walled carton made of 350 pound test material is adequate.
- c. Use enough shock absorbing material ( a 3 to 4 inch layer ) around all sides of the unit to provide a firm cushion and to prevent the unit from moving inside the container.
- d. Seal the shipping container securely.
- e. Mark the shipping container **FRAGILE** to ensure careful handling.
- f. In any correspondence, refer to unit by its model number and the full serial number.

**NOTE**

If you ever need to return the 41951A for servicing, HP recommends that you return your 4195A also so that system performance can be verified after repairs are made.

## SECTION 3

## OPERATION

**3-1. INTRODUCTION**

This section provides the information necessary to use the 41951A. **WARNINGS, CAUTIONS,** and **NOTES** are given throughout, and they should be followed to insure operator safety and serviceability of the unit.

**NOTE**

For detailed information on 4195A operation, refer to the 4195A's Operation Manual.

**3-2. BLOCK DIAGRAM**

The Impedance Test Adapter's block diagram is shown in Figure 3-1. The number included in Figure 3-1, indicates the insertion loss of the Impedance Test Adapter when the 41951A is connected to the HP 4195A, and the  $50\ \Omega$  load is connected to the measurement terminal (APC-7 connector) of the Impedance Test Adapter. The output signal to the **OUTPUT R** connector is approximately 18 dB lower than the input signal to the **INPUT S** connector, and the output signal to the DUT is approximately 12 dB lower than the input signal (the voltage applied to DUT is about a quarter of the voltage supplied from the 4195A).

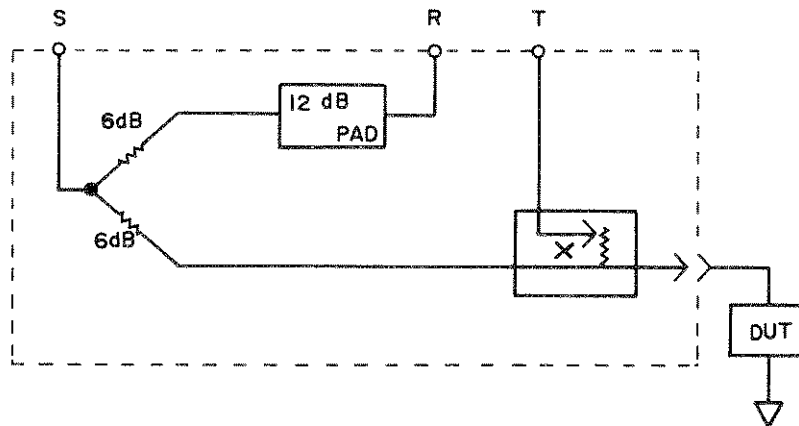


Figure 3-1. Impedance Test Adapter's Block Diagram

**3-3. APC-7 CONNECTOR**

The 41951A's measurement terminal is an APC-7 connector. This connector provides the capability for connecting and installing an accessory test fixture matched to the 41951A, or a user-built test fixture. The APC-7 connector test port, a two-terminal configuration, has a characteristics impedance of  $50\ \Omega$  which is equal to the base impedance in reflection coefficient measurements. This base impedance represents the reference in the normalized impedance calculations for multiple parameter derivations.

The connecting surface of the APC-7 connector, the calibration standards, and the test fixtures must be kept free of spots, dust, oil and adhesives which will cause poor contact. To maintain clean contact surfaces, it is recommended that the operator perform periodic cleaning as necessary. Use a lint-free cloth and, if a cleaning fluid is needed, use isopropyl alcohol.

### CAUTION

**Do not use aromatic or chlorinated hydrocarbons, esters, ethers, terpenes, higher alcohols, ketones, or ether-alcohols such as benzene, toluene, turpentine, dioxane, gasoline, cellulose acetate, or carbon tetrachloride. Keep exposure of the connector parts to both the cleaning fluid and its vapors as brief as possible.**

### 3-4. CONNECTING TEST FIXTURE

The following five test fixture are available for the impedance measurement using the 41951A with the 4195A ( see Table 1-3 ).

HP 16091A	Coaxial Fixture
HP 16092A	Spring Clip Fixture
HP 16093A/B	Binding Post Fixture
HP 16094A	Probe Fixture

The test fixture is installed by connecting to the APC-7 connector on 41951A's Impedance Test Adapter. For the details, refer to the test fixtures' operation notes.

### 3-5. MEASUREMENT CALIBRATION CONSIDERATIONS

The 4195A provides the one port full calibration, port extension, and offset compensation capabilities for accurate impedance measurement. One port full calibration corrects for the measurement errors caused by the measurement instrument and Impedance Test Adapter. Port extension compensates for phase shifts in extension cables that connects the calibration plane and the DUT. Offset compensates for the measurement errors caused by the residual impedance and stray admittance, between the calibration plane and DUT. For details of the measurement calibration, refer to the 4195A's Operation Manual.

At the measurement which can perform the offset compensation at the measurement terminal, the one port full calibration and offset compensation should be performed. If the measurement terminal is extended using 50  $\Omega$  low loss cable ( as the air line ), or the offset compensation cannot be performed at the measurement terminal, the port extension should be performed instead of the offset compensation. If needed, all measurement calibration procedures can be performed under actual measurement conditions.

#### 3-5-1. ONE PORT FULL CALIBRATION

The one port full calibration compensates for the measurement errors due to the frequency of the Impedance Test Adapter. This calibration is required to extend the calibration plane to the connecting surface of the APC-7 connector of the Impedance Test Adapter or the extended measurement terminal ( see Figure 3-2 ). If the measurement terminal is extended by a cable with APC-7 connectors, the one port full calibration should be performed at the

extended measurement terminal. To perform one port full calibration, three calibration standards; 0S, 0  $\Omega$ , 50  $\Omega$ , are required. For the procedure of the one port full calibration, refer to the 4195A's Operation Manual.

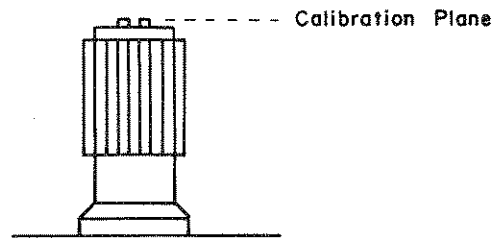


Figure 3-2. 41951A's Calibration Plane

The reference values of the furnished calibration standards are listed in Table 3-1.

Table 3-1. Reference Values for Calibration Standards

Standard	Reference Value
0 S admittance	$0 \text{ S} + j \times \omega \times 82 \text{ fF}$
0 $\Omega$ impedance	$0 \Omega + j \times \omega \times 0 \text{ H}$
50 $\Omega$ impedance	$50 \Omega + j \times \omega \times 0 \text{ H}$

These values are stored in the 4195A's battery back-up memory as the calibration reference values.

#### NOTE

If you extend the calibration plane beyond the connecting surface of the APC-7 connector, and you have accurate standards that can be connected to the end of the extension, calibration will be accurate to the end of the extension. Refer to the 4195A's Operation Manual for the procedure for entering the reference values of your standards.

#### 3-5-2. PORT EXTENSION

The port extension compensates for the phase shift in the extension cable. This capability is effective when the measurement terminal is extended by the 50  $\Omega$  low loss cable as the air line, or when the offset compensation cannot be performed. For procedure of the port extension capability, refer to the 4195A's Operation Manual.

#### 3-5-3. OFFSET COMPENSATION

The 4195A applies three offset compensation; 0S & 0 $\Omega$  offset, 0S offset, and 0 $\Omega$  offset compensation. The 0S & 0 $\Omega$  offset compensates for the residual impedance and stray admittance existing in the test fixture, that is attached on an Impedance Test Adapter. The 0S

offset compensates for the stray admittance, and the 0Ω offset compensates for the residual impedance.

To perform the offset compensation, select the offset compensation mode by pressing the '0S OFFSET', '0Ω OFFSET' or '0S&0Ω OFFSET' softkey. If the 0S & 0Ω offset compensation is selected, the '0S' and '0Ω' softkeys are displayed on the softkey area. If the 0S offset or 0Ω offset compensation is selected, one of these softkeys is displayed. To perform the offset compensation, short ( or open ) the measurement terminal on the test fixture, and press the '0Ω ( or 0S )' softkey and ENTER/EXECUTE key.

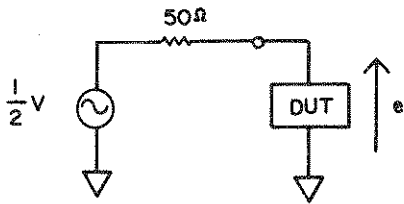
**NOTE**

The test fixture must be configured the same as it will be for performing compensation and for making a measurement.

**3-6. TEST SIGNAL LEVEL AND OUTPUT IMPEDANCE**

The test signal level applied to DUT depends on the test signal level applied from the 4195A, the output impedance and insertion loss of the Impedance Test Adapter, and the impedance of DUT. The 41951A's output impedance is approximately 50 Ω.

The equivalent circuit and equation to calculate the test signal level is shown in Figure 3-3.



$$e = V \times ZL / \{ 2 \times ( ZL + 50 ) \} [V]$$

Where V: 4195A's output Signal Level [V]  
 ZL: Impedance of DUT [Ω]  
 e: Test Signal Level at DUT

Figure 3-3. Test Signal Level Calculation

The calculation example of the test signal level at DUT is shown in Table 3-2.

Table 3-2. Test Signal Level

Impedance of DUT	4195A's Signal Level Setting	
	0dBm	1V
infinite	112 mV	0.5 V
1 kΩ	106 mV	0.48 V
100 Ω	75 mV	0.33 V
50 Ω	56 mV	0.25 V



### 3-7. DC BIAS

#### 3-7-1. Internal DC Bias

To use the 4195A's internal DC bias capability, connect the furnished BNC cable between the 4195A's **DC SOURCE OUTPUT** connector and the 41951A's **DC SOURCE INPUT** connector.

#### 3-7-2. External DC Bias

External DC bias can be used up to  $\pm 40$  V and  $\pm 500$  mA.

**CAUTION**

**DO NOT SHORT CIRCUIT WHEN AN EXTERNAL A DC BIAS IS APPLIED, OR YOU WILL BLOW THE FUSE IN THE IMPEDANCE TEST ADAPTER.**

**CAUTION**

**DO NOT PERFORM A CALIBRATION MEASUREMENT WHILE A DC BIAS IS APPLIED. THE CALIBRATION STANDARDS MAY BE DAMAGED IF YOU DO.**



## SECTION 4

### VERIFICATION TEST

#### 4-1. INTRODUCTION

This section contains the basic operational checkout procedures for the HP 41951A. All tests can be performed without access to the interior of the 41951A. The verification test is typically used for incoming inspection of the 41951A, and to verify that the Impedance Test Adapter is in good order after it has been repaired.

#### 4-2. EQUIPMENT REQUIRED

Table 4-1 lists the equipment required to perform the verification test. Equipment that meets or exceeds the critical specifications listed in the table may be used as a substitute for the recommended models. The equipment used for verification testing must be calibrated.

Table 4-1. Recommended Test Equipment

Equipment	Critical Specifications	Recommended Model
Network Analyzer	Frequency: 100 kHz to 500 MHz Impedance: 50 $\Omega$ Accuracy: $\pm 0.5$ dB	HP 4195A
Digital Multimeter	Resistance Measurement Range: 5 to 30 $\Omega$ Accuracy: $\pm 1\%$	HP 3478A
Power Splitter	Frequency: 100 kHz to 500 MHz Input Impedance: 50 $\Omega$ Output Impedance: 50 $\Omega$	HP 11667A

#### 4-3. CALIBRATION CYCLE

The 41951A requires periodic performance verification. The 41951A (Impedance Test Adapter) should be checked out using the verification test at least once a year or more depending on the frequency of use. Preventive maintenance should be performed at least twice a year to keep down-time to a minimum, and to insure optimum operation,

#### 4-4. DC BIAS PATH CHECK

This test checks the resistance of the path between the 41951A's **DC SOURCE INPUT** connector and the APC-7 connector.

#### REQUIRED EQUIPMENT:

Digital Multimeter	HP 3478A
APC-7 to N(f) Adapter ( 1 ea. )	HP 11524A
Test Leads	

#### PROCEDURE:

1. Connect the Test Leads to the Digital Multimeter's high and low terminals.
2. Connect the APC-7 to N(f) Adapter to the Impedance Test Adapter's APC-7 connector.
3. Set the Digital Multimeter to the resistance measurement mode.
4. Connect a tip of the Test Lead connected to the DMM high input to the center conductor of the Impedance Test Adapter's **DC SOURCE INPUT** connector, and the tip of the Test Lead connected to the DMM's low input to the center conductor of the APC-7 to N(f) Adapter connected to the Impedance Test Adapter's APC-7 connector.
5. Check that the Digital Multimeter's reading is less than 10  $\Omega$ .

#### 4-5. RF PATH CHECK

This test checks the RF path of the Impedance Test Adapter.

#### REQUIRED EQUIPMENT:

Network Analyzer	HP 4195A
Power Splitter	HP 11667A
N(m)-BNC(f) Adapter ( 4 ea. )	HP 1250-0780
BNC(m)-BNC(m) Cable ( 2 ea. )	HP 8120-1838

#### NOTE

The N(m)-N(m) Cable ( 2 ea. : HP 11500B ) can be used instead of the N(m)-BNC(f) Adapter ( 4 ea. ) and BNC(m)-BNC(m) Cable ( 2 ea. ).

#### PROCEDURE:

1. Set the Network Analyzer as follows.

Source:	Frequency:	100 kHz to 500 MHz, Log sweep
	OSC Level:	+5 dBm
	DC Bias:	OFF

Receiver:	RBW:	1 kHz
	INPUT RANGE R-ch:	0 dBm
	T-ch:	0 dBm

2. Connect the Power Splitter to the Network Analyzer, as shown in Figure 4-1 (1).

#### NOTE

Use the N(m) to N(m) Adapter included with the 41951A to connect the Power Splitter's **INPUT** terminal to the Network Analyzer's **SOURCE** terminal,

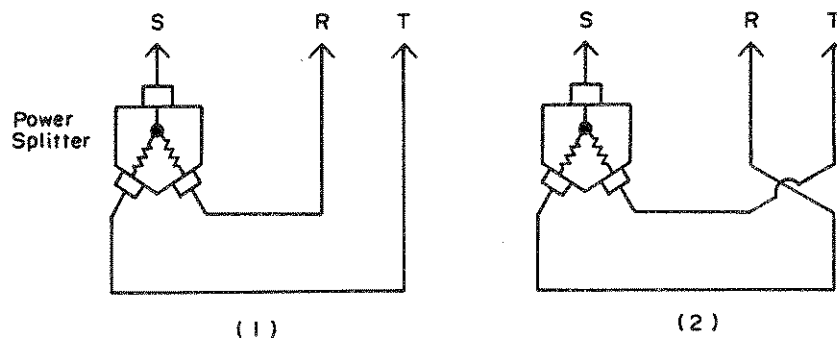


Figure 4-1. Power Splitter Connection

3. Measure the T/R and store the data ( data  $D_1$  ). All measured data in the measurement range, must be stored. This data is used to calculate the compensation data.
4. Swap the cable connection with the Adapter at the Network Analyzer's INPUT port ( do not try to swap the cables at the Power Splitter's OUTPUT ), as shown in Figure 4-1 (2).
5. Measure the T/R and store the data ( data  $D_2$  ).
6. Perform the following calculation, and store the result ( data  $D_3$  ). Data  $D_3$  is used as the compensation data, in the following steps.
$$D_3 = \{ ( \text{data } D_1 ) + ( \text{data } D_2 ) \} / 2$$
7. Connect the Impedance Test Adapter to the Network Analyzer ( refer to paragraph 2-3, INTERCONNECTION ).
8. Connect the 0S Calibration Standard ( OPEN ) to the APC-7 connector of the Impedance Test Adapter, and measure the T/R.
9. Compensate the measured data by subtracting data  $D_3$  from the measured data. Confirm that the compensated data is  $0 \pm 3$  dB.
10. Connect the  $0 \Omega$  Calibration Standard ( SHORT ) to the APC-7 connector of the Impedance Test Adapter, and measure the T/R.
11. Compensate the measured data by subtracting data  $D_3$  from the measured data. Confirm that the compensated data is  $0 \pm 3$  dB.
12. Connect the  $50 \Omega$  Calibration Standard ( LOAD ) to the APC-7 connector of the Impedance Test Adapter, and measure the T/R.
13. Compensate the measured data by subtracting data  $D_3$  from the measured data. Confirm that the compensated data is less than -30 dB.

#### NOTE

In steps 9, 11 and 13, the compensation can be performed easily, by using the 4195A's User Math capability. If the compensation data is stored in the 4195A's RA register, the following equation should be entered.

$$\text{DMA} = \text{MA} - \text{RA}$$

For the details of the User Math capability, refer to the 4195A's Operation Manual.

*SECTION 5*  
*MANUAL CHANGES*

**5-1. INTRODUCTION**

This section contains information for adapting this manual to instruments to which its contents do not directly apply. The following paragraphs explain how to adapt this manual to older instruments which have a serial prefix/number lower than that given on the title page.

**5-2. MANUAL CHANGES**

To adapt this manual to your instrument, refer to Table 5-1 and make all of the manual changes listed opposite your instrument's serial number. Perform these changes in the sequence given.

If your instrument serial number is not listed on the title page of this manual or in Table 5-1, it may be documented in a yellow MANUAL CHANGES supplement. For additional information about serial number coverage, refer to UNITS COVERED BY THIS OPERATION NOTE in Section 1.

Table 5-1. Manual Changes by Serial Number

Serial Prefix or Number	Make Manual Changes





## SECTION 6

### SERVICE

#### 6-1. INTRODUCTION

This section provides the information required to service the 41951A Impedance Test Kit. The Schematic Diagram, and the Replaceable Parts List are included.

#### 6-2. SCHEMATICS AND REPLACEABLE PARTS

The 41951A consists of the assemblies listed in Table 1-2. Any assembly except for the Impedance Test Adapter, can be replaced by the assembly level, when it is damaged. The part numbers are shown in Figure 1-1, and Table 1-2.

The Impedance Test Adapter includes some replaceable parts. Figure 6-1 shows the schematic diagram of the Impedance Test Adapter. The replaceable parts mounted on the board in the Impedance Test Adapter, is listed in Table 6-1. The part's locations are shown in Figure 6-2.

#### NOTE

Parts that are not listed in Table 6-1 cannot be replaced, and the board assembly cannot be replaced. So if any of parts which are not listed are damaged, the Impedance Test Adapter must be replaced at the assembly level.

Table 6-2 shows an exploded view of the APC-7 connector mounted on the Impedance Test Adapter's top cover, and lists the APC-7 connector's parts. Table 6-3 lists the Impedance Test Adapter's replaceable parts except for those on the board, and shows their location.

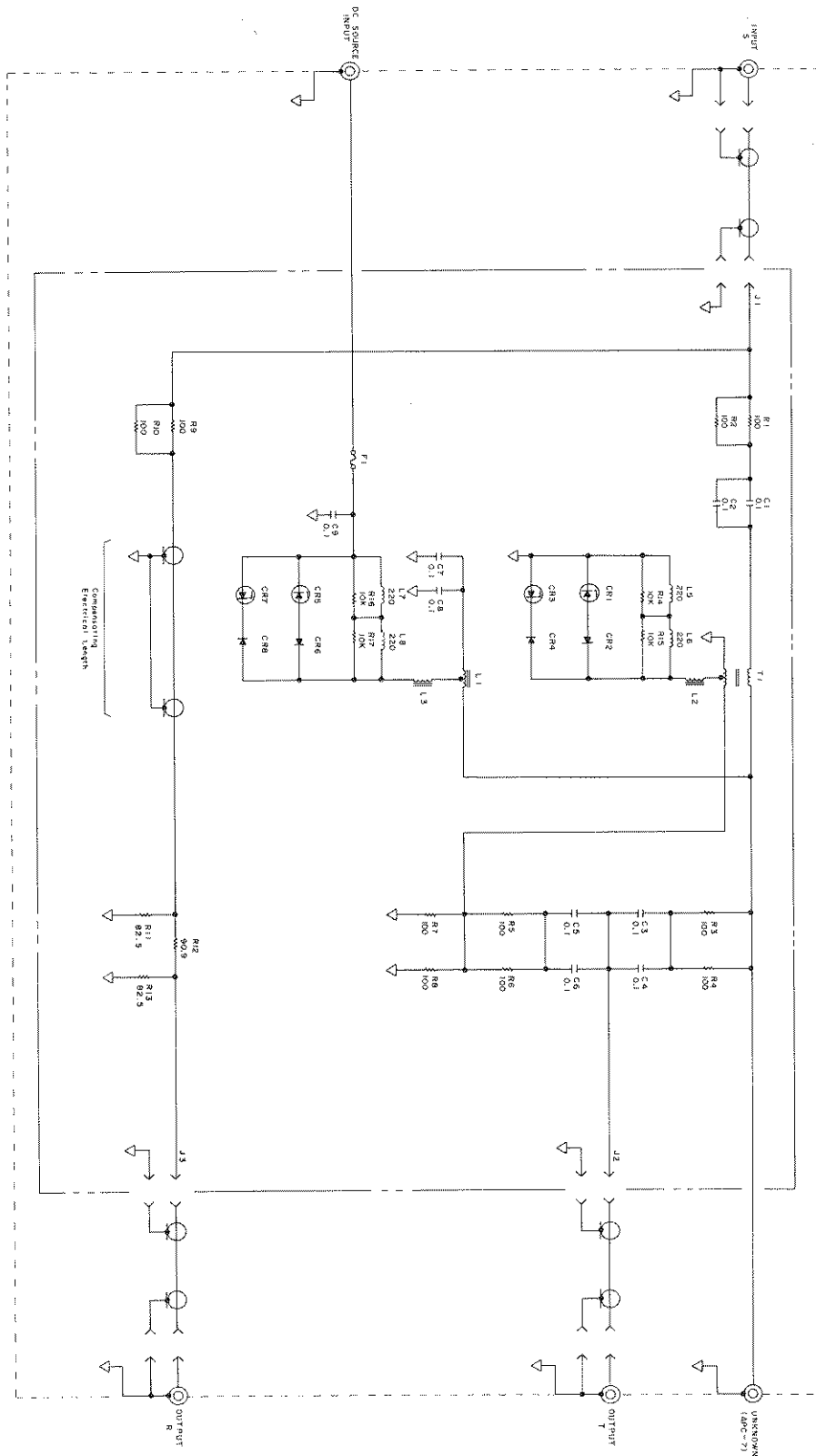


Figure 6-1. Schematic Diagram of the Impedance Test Adapter

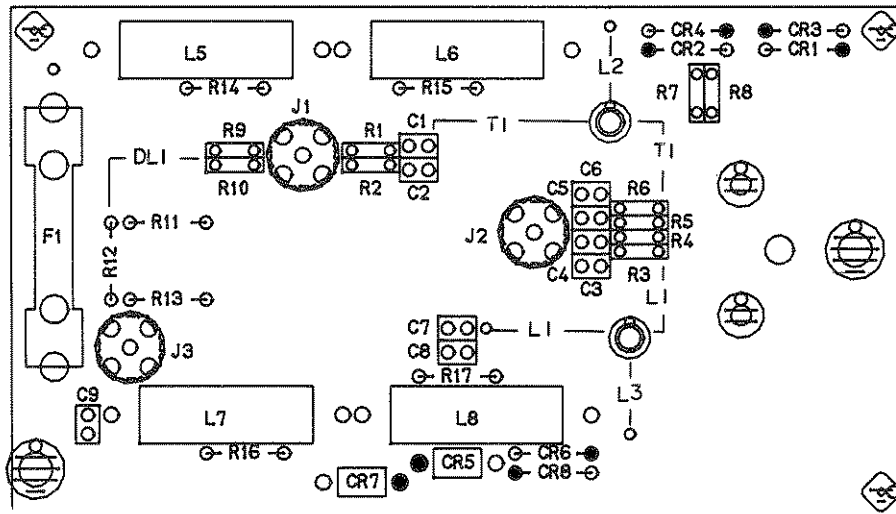
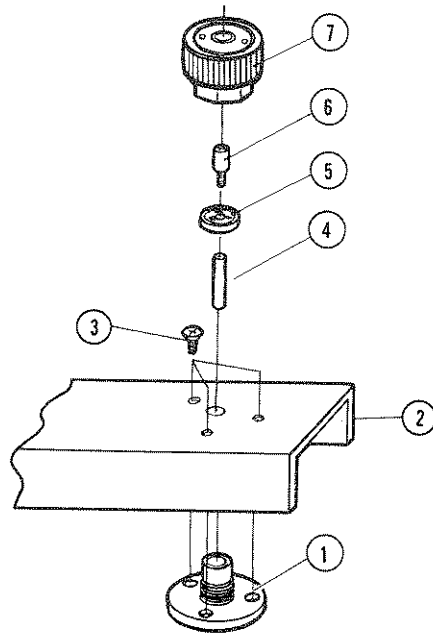


Figure 6-2. Parts Locations

Table 6-1. Replaceable Parts List

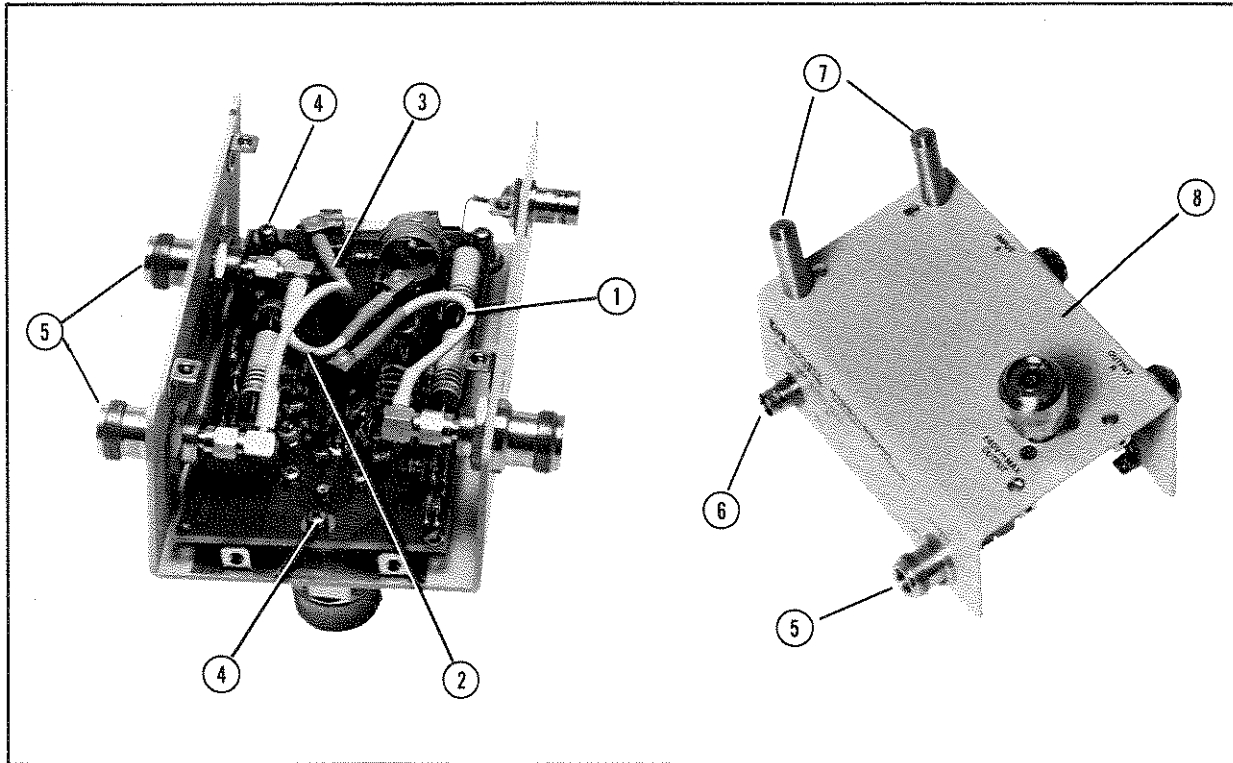
Reference Designator	HP Part Number	Description
C1	0160-0576	Capacitor 1 $\mu$ F
C2	0160-0576	Capacitor 1 $\mu$ F
C4	0160-0576	Capacitor 1 $\mu$ F
C5	0160-0576	Capacitor 1 $\mu$ F
C7	0160-0576	Capacitor 1 $\mu$ F
C8	0160-0576	Capacitor 1 $\mu$ F
C9	0160-0576	Capacitor 1 $\mu$ F
CR1	1902-0953	Diode Zener
CR2	1901-0050	Diode Switching
CR3	1902-0953	Diode Zener
CR4	1901-0050	Diode Switching
CR5	1902-0551	Diode Zener
CR6	1901-0050	Diode Switching
CR7	1902-0551	Diode Zener
CR8	1901-0050	Diode Switching
F1	2110-0001	Fuse 1 A 250 V
J1	1250-0835	Connector-RF SMC
J2	1250-0835	Connector-RF SMC
J3	1250-0835	Connector-RF SMC
L5	5080-3244	Inductor 220 $\mu$ H
L6	5080-3244	Inductor 220 $\mu$ H
L7	5080-3244	Inductor 220 $\mu$ H
L8	5080-3244	Inductor 220 $\mu$ H
R1	0698-7212	Resistor 100 $\Omega$
R2	0698-7212	Resistor 100 $\Omega$
R13	0757-0399	Resistor 82.5 $\Omega$
R14	0757-0442	Resistor 10 k $\Omega$
R15	0757-0442	Resistor 10 k $\Omega$
R16	0757-0442	Resistor 10 k $\Omega$
R17	0757-0442	Resistor 10 k $\Omega$

Table 6-2. APC-7 Connector



Reference Designator	HP Part Number	Qty.	Description
1	41951-21001	1	Flange
2	41951-04001	1	Top Cover
3	0515-0914	3	Screw
4	41951-23001	1	Center Conductor
5	5040-0306	1	Insulator
6	1250-0816	1	Connector-RF
7	1250-1466	1	Connector-RF APC-7 ( with a cap )

Table 6-3. Replaceable Parts List ( except for board )



Reference Designator	HP Part Number	Qty.	Description
1	41951-61604	1	Cable Assembly
2	41951-61601	1	Cable Assembly
3	41951-61603	1	Cable Assembly
4	0515-1550	5	Screw
5	1250-1811	3	N(f)-SMA(f) Adapter ( with Nut and Washer )
6	1250-0083	1	Connector-RF BNC
	2190-0016	1	Washer
	2950-0001	1	Nut
7	41951-24001	2	Post
	2190-0084	2	Washer
	2950-0006	2	Nut
8	41951-04001	1	Top Cover
	41951-04002	1	Bottom Cover
	0515-0914	8	Screw
	6960-0016	3	Plug-Hole











Part No. 41951-90000

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