

# Operation Note

## 11940C Close-Field Probe



Part No. CK-11940-90007  
Printed in USA Jan 2013

# Notice

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## Product Transition

Under the authorization of Agilent Technologies, Cokeva, Inc. is offering the 11940C as a direct replacement for the Agilent 11940A. The 11940C provides the functionality and reliability you expect.

## Contacting Cokeva Sales and Service Office

For more information, please contact us at:

Cokeva, Inc.  
9000 Foothills Blvd, Roseville, CA 95747 USA  
[www.cokeva.com](http://www.cokeva.com)  
[sales@cokeva.com](mailto:sales@cokeva.com)  
Tel: +1 916.462.6000

Business hours: Mon – Fri | 8:00 AM - 4:30 PM (Pacific Standard Time)

In any correspondence or telephone conversation, please refer to your instrument by its model number and full serial number.

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## **Certification**

Cokeva, Inc. certifies that this product met its published specifications at the time of shipment from the factory.

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## **Warranty**

This Cokeva, Inc. product is warranted against defects in material and workmanship for a period of one year from date of shipment or for the length of a purchased warranty extension if applicable. During the warranty period, Cokeva, Inc. will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to Cokeva, Inc. Buyer shall prepay shipping charges to Cokeva, Inc. and Cokeva, Inc. shall pay shipping charges to return the product to Buyer. Buyer shall pay all shipping charges, duties, and taxes for products returned to Cokeva, Inc. from another country.

Cokeva, Inc. warrants that its software and firmware designated by Cokeva, Inc. for use with an instrument will execute its programming instructions when properly installed on that instrument. Cokeva, Inc. does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error-free.

### **LIMITATION OF WARRANTY**

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance or calibration by Buyer or by vendors not approved by Cokeva, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. COKEVA SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

### **EXCLUSIVE REMEDIES**

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. COKEVA, INC. SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.


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## **Assistance**

*For any assistance, contact the Cokeva, Inc. Sales and Service Office at +1 916.543.7600 between 8:00 AM – 4:30 PM (PST), Mon – Fri.*

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## SAFETY SYMBOLS

The following safety symbols are used throughout this manual and in the instrument. Familiarize yourself with each of the symbols and its meaning before operating this instrument.



Instruction manual symbol. The instrument will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect the instrument against damage. Location of pertinent information within the manual is indicated by use of this symbol in the table of contents.



Indicates dangerous voltages are present. Be extremely careful.



The CAUTION sign denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in damage to or destruction of the instrument. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.



The WARNING sign denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

**1-1. GENERAL INFORMATION****1-2. Description**

1-3. The Cokeva 11940C Close-Field Probe is a hand-held, electromagnetic-field sensor designed to make repeatable, calibrated magnetic field measurements from 30 MHz to 1 GHz. It is optimized for the location and measurement of sources of electromagnetic interference (EMI) in electronic equipment. The Cokeva 11940C can also be used as a localized magnetic field source when operated in conjunction with an appropriate signal generator, thereby allowing circuit board level susceptibility testing of instruments.

Included in Shipment:

ITEM	DESCRIPTION	QTY
11940C	Close field probe, hand held, 30 MHz to 1 GHz	1
9320-6720	China RoHS Addendum for Accessories	1
1250-1250	Adapter-Coaxial Straight Male-N Female-SMA	1
1250-1700	Adapter-Coaxial Straight Male-BNC Female-SMA	1
8120-4811	Cable Assembly – Coaxial	1
CK-11940-90007	Operation Note	1

**1-4. Initial Inspection**

1-5. If the shipment contents are incomplete or damaged, notify the Cokeva office. If the shipping container is damaged, or the cushioning material shows signs of stress, notify the carrier as well as the Cokeva office. Keep the shipping materials for the carrier's inspection. The Cokeva office will arrange for repair or replacement without waiting for a claim settlement.

1-6. See Paragraph 4-1 for Operation Verification.

**2-1. SPECIFICATIONS**

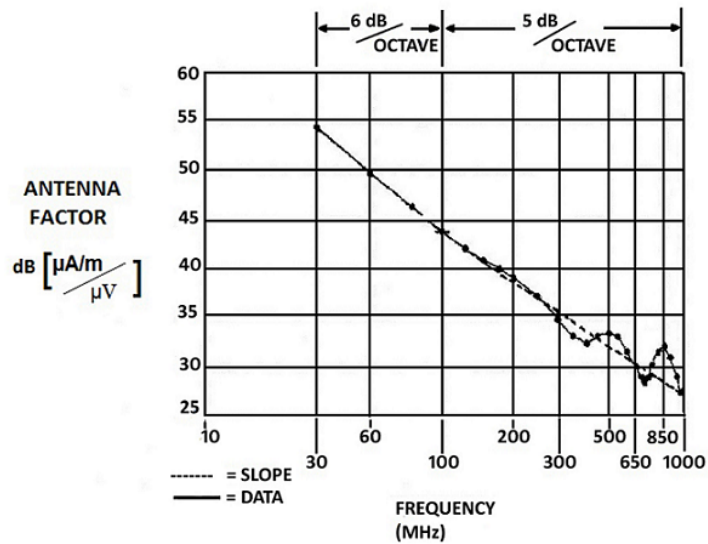
2-2. Specifications for the Cokeva 11940C are listed in Table 1. An asterisk (\*) placed after an entry indicates a supplemental characteristic. Supplemental characteristics are not specifications but are characteristics included as additional information for the user.

2-3. Figure 1 illustrates the characteristic frequency response for the Cokeva 11940C Close-Field Probe. See Section 3-4, Antenna Factors, for additional information.

Table 1. Cokeva 11940C Specifications

Antenna Factor:	Measured for each unit at 30, 100, 500, 850, and 1000 MHz to within $\pm 2$ dB in a 377 ohm field impedance. See Figure 1 for characteristic antenna factor data.	<p>DIMENSIONS IN MILLIMETERS AND (INCHES)</p>
Temperature Range:*	0°C to +40°C: $<\pm 1$ dB (Operating) -10°C to +65°C (Storage)	
Frequency Range:	30 MHz - 1 GHz	
Connector:	SMA, replaceable barrel	
Maximum Input Power:	0.5 watts	
VSWR:*	$<3:1$	
Maximum voltage at tip:*	1 kV (dc + peak ac)	
Weight:*	Net: 0.10 kg (0.4 lbs) Shipping: 0.56 kg (1.2 lbs)	
*supplemental characteristic		

Figure 1. Cokeva 11940C Characteristic Antenna Factors. 30 MHz-1 GHz



### 3-1. OPERATION

#### 3-2. Theory of Operation

3-3. The Cokeva 11940C is a balanced magnetic field sensor that provides an output voltage proportional to the strength of the magnetic field at its tip. Radiated magnetic fields couple directly to the Cokeva 11940C and produce an output signal; radiated electric fields also couple to the Cokeva 11940C but do not produce an output voltage due to the construction of the probe. The Cokeva 11940C uses a dual-loop sensor and a balun to reject electrically coupled signals. See Figure 2. The probe preserves frequency information and is ideally suited for use with a spectrum analyzer. The Cokeva 11940C circuitry is passive and therefore only contributes thermal noise to any measurement system. Inspect the probe tip for damage before using.

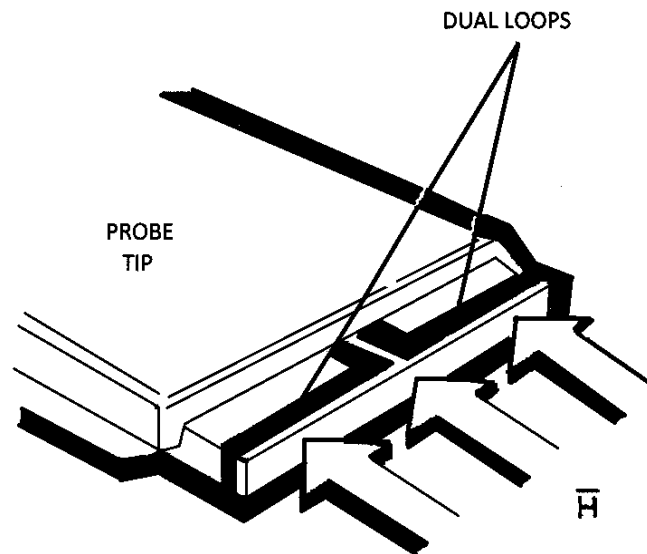


Figure 2. Magnetic Field Orientation for Maximum Coupling

#### 3-4. Antenna Factors

3-5. The Cokeva 11940C is supplied with a calibration table mounted on its side. The table provides antenna factors at five calibration points: 30 MHz, 100 MHz, 500 MHz, 850 MHz, and 1000 MHz. The antenna-factor units used in this table,  $\text{dB}(\mu\text{A}/\text{m}/\mu\text{V})$ , are accurate to  $\pm 2$  dB in a 377 ohm field impedance. Add the antenna-factor units to the measured voltage in  $\text{dB}\mu\text{V}$  indicated on the spectrum analyzer to give magnetic-field strength in  $\text{dB}(\mu\text{A}/\text{m})$ . Refer to the following equation:



$$\bar{H}\text{-Field Strength} \left( \text{dB} \frac{\mu\text{A}}{\text{m}} \right) = V_{\text{SA}} + \text{AF} + K$$

where

$V_{\text{SA}}$  = voltage in dB $\mu$  V measured on analyzer

AF = 11940C Antenna Factor in dB  $\left( \frac{\mu\text{A}/\text{m}}{\mu\text{V}} \right)$

K - loss or gain in dB between 11940C and spectrum analyzer  
(Positive value if loss, negative value if gain.)

3-6. Use the data included in Figure 1 for interpolating antenna factors between the five calibration frequencies included in the probe's calibration table.

3-7. The probe may be used below 30 MHz and above 1000 MHz without calibration and with reduced electric field rejection. See Figure 3 for characteristic antenna factors below 30 MHz.

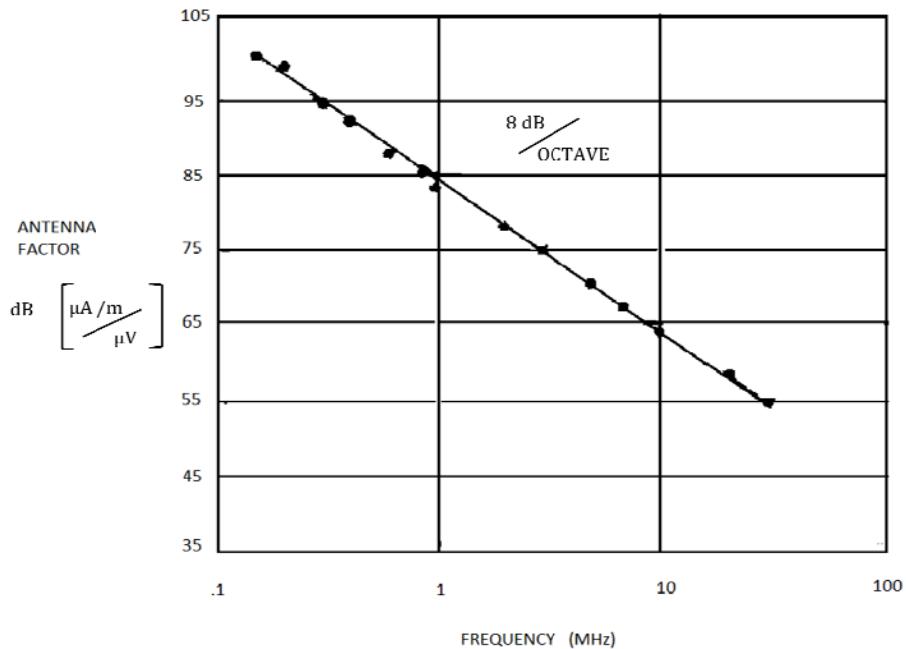


Figure 3. Cokeva 11940C Characteristic Antenna Factors below 30 MHz

**3-8. Power Density and Electric Field Calculations**

3-9. The Cokeva 11940C measures magnetic field strength. Assuming a 377-ohm field impedance, an associated electric field strength or a wave power density can be calculated from the magnetic field measurement. Refer to the following equations:

$$\begin{aligned} \text{E-Field Strength } \left( \text{dB } \frac{\mu\text{V}}{\text{m}} \right) &= V_{SA} + AF + K + 51.5 \\ &= V_{SA} + AF + K + 51.5 \end{aligned}$$

$$\text{Power Density } \left( \text{dB } \frac{\text{mW}}{\text{cm}^2} \right) = V_{SA} + AF + K - 104.3$$

where

$V_{SA}$  = voltage in dB $\mu$ V measured on analyzer

AF = 11940C Antenna Factor in dB  $\left( \frac{\mu\text{A/m}}{\mu\text{V}} \right)$

K = loss or gain in dB between 11940C and spectrum analyzer  
(Positive value if loss, negative value if gain.)

EXAMPLE:

At 100 MHz, measured  $V_{SA} = 60.3$  dB $\mu$ V. Let  $K = 0$  and  $AF = 44$  dB  $\left( \frac{\mu\text{A/m}}{\mu\text{V}} \right)$

then

$$E \left( \text{dB } \frac{\mu\text{V}}{\text{m}} \right) = 60.3 + 44 + 51.5 = 155.8 \text{ dB}\mu\text{V/m} = 61.7 \text{ V/m}$$

$$S \left( \text{dB } \frac{\text{mW}}{\text{cm}^2} \right) = 60.3 + 44 - 104.3 = 0 \text{ dB } \frac{\text{mW}}{\text{cm}^2} = 1 \frac{\text{mW}}{\text{cm}^2}$$

**3-10. Localized Field Source**

3-11. The probe can also be used as a localized magnetic field source for locating susceptibility problems on an electronic circuit. It is a reciprocal device; that is, a voltage fed into the unit will create a magnetic field at the dual-loop sensor. For this application, the maximum input power is 0.5W with a characteristic worst-case VSWR of 3:1. Table 2 lists characteristic magnetic field strengths developed at the probe tip using 0 dBm incident power.

**Table 2. Characteristic Magnetic Field Strength**

Frequency (MHz)	Input Power (incident)	Magnetic Field Strength ( $\bar{H}$ ), dB ( $\mu\text{A/m}$ )
30	0 dBm	101
100	0 dBm	98
500	0 dBm	94
850	0 dBm	93
1000	0 dBm	98

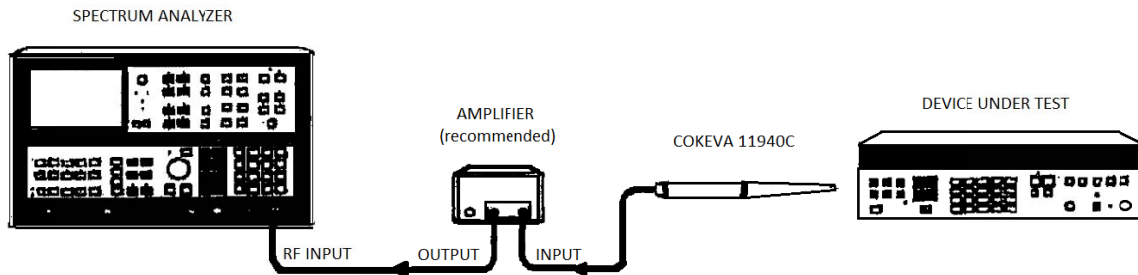
**3-12. Test Setups**

3-13. The Cokeva 11940C operates as either a localized magnetic field probe or localized magnetic field source. The following paragraphs describe different applications and test setups for the probe. Table 3 lists the recommended test setup equipment used in these examples. Any equipment that satisfies the critical specifications listed in Table 3 may be substituted for the recommended equipment. When used as a probe, be sure to add the antenna-factors and cable losses to the signal levels indicated on the spectrum analyzer. If a preamplifier is used to increase measurement sensitivity, subtract its gain from the displayed signal level.

**WARNING**

**The dielectric material on the tip of the probe has a characteristic breakdown voltage of 1 kV. To prevent damage to the probe and/or personal injury to the user, the probe should not be used where a potential of over 1 kV is available.**

3-14. Emissions Test Setup: Figure 4 illustrates the basic configuration used for detecting EMI emissions.



**Figure 4. Emissions Test Setup**

3-15. Stimulus Response Test Setup: The relative shielding effectiveness of various enclosures and shielded structures can be tested using stimulus response techniques. See Figure 5. The tracking generator output signal radiates from an antenna placed inside the enclosure under test, while the probe and spectrum analyzer provide frequency and relative amplitude information. See Section 3-17 for proper probe placement.

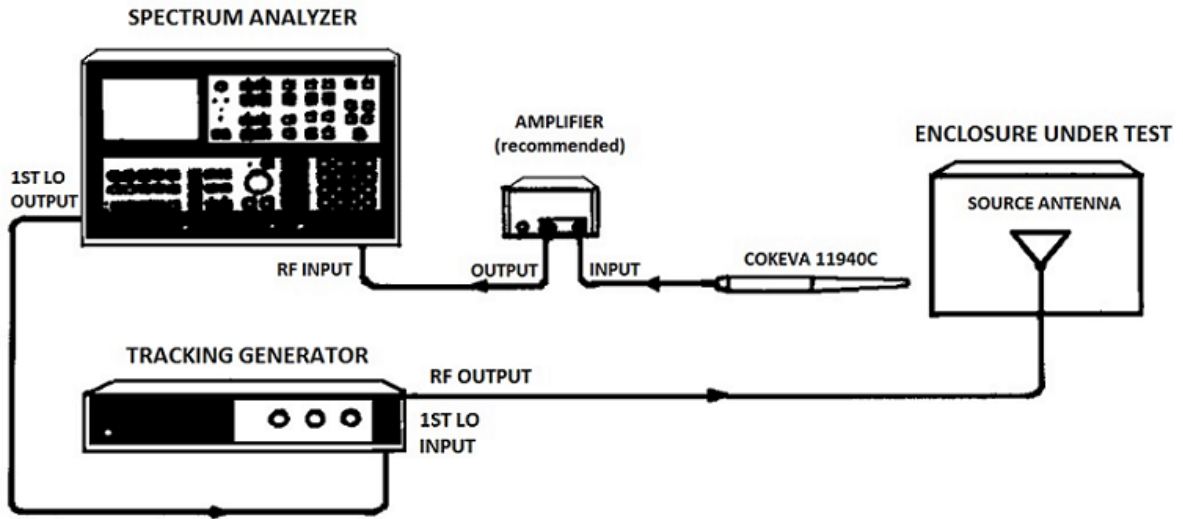


Figure 5. Stimulus Response Test Setup

3-16. Source Test Setup: Used as a field source, the probe provides a magnetic field for susceptibility testing of electronic circuits. For broadband susceptibility testing, use the probe with a swept or tracking source. See Figure 6 for an example of the basic localized field source test setup.

**CAUTION**

Power applied to the probe must not exceed the maximum input power listed in Table 1 or damage to the probe will result.

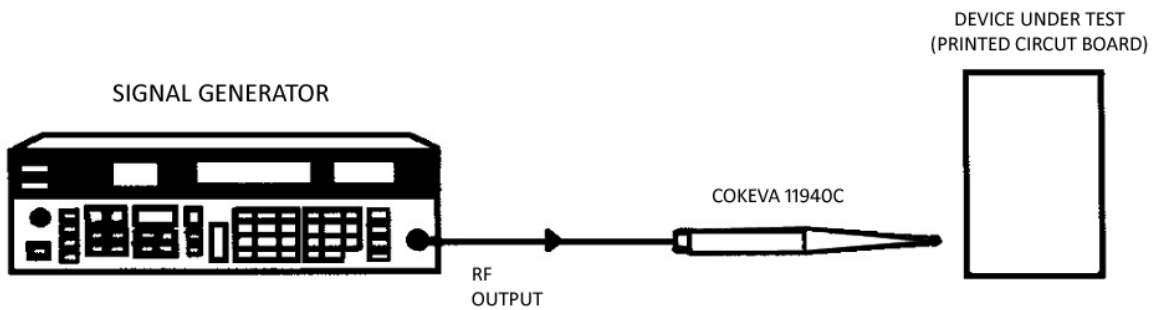


Figure 6. Source Test Setup

Instrument	Critical Specifications	Recommended Model
Spectrum Analyzer	Frequency Range: 30 MHz – 1 GHz	HP 8567A (10 kHz – 1.5 GHz) HP 8568B (100 Hz – 1.5 GHz) HP 8566B (100 Hz – 22 GHz)
Tracking Generator	Frequency Range: 30 MHz – 1 GHz	HP 8444A, Option 059 (100 MHz – 1.5 GHz) For use with HP 8567A or HP 8568B
Signal Generator	Frequency Range: 30 MHz – 1 GHz	HP 8656B (0.1 – 990 MHz)
Preamplifier*	Frequency Range: 30 MHz – 1 GHz RF Gain: 20 dB	HP 8447D (100 kHz – 1.3 GHz) (Gain >26 dB)
* HP 85685A RF Preselector may be substituted if a spectrum analyzer listed above is used.		

**Table 3. Recommended Test Setup Equipment**

**3-17. Measurement Techniques**

3-18. The probe is designed to be held very close to potential radiating points. The plane of the probe tip loops must be perpendicular to the radiating magnetic field as illustrated in Figure 2. For example, if the seam of an enclosure is being tested for EMI, hold the probe as illustrated in Figure 7. When measuring the radiation from a coaxial cable, position the probe tip as shown in Figure 8. The side of the probe with the calibration label should be facing away from the cable being measured.

3-19. The probe may be used as a source in susceptibility testing as described in Section 3-11 and Paragraph 3-16. In this application, hold the probe within 1 cm of the electronic circuit component being tested.

**4-1. OPERATION VERIFICATION**

4-2. Operation Verification for the Cokeva 11940C consists of the Return Loss Measurement Test included in this section. Actual antenna factor verification requires a calibrated broadband magnetic field. A return loss measurement provides a reliable alternate method of determining the probe's electrical integrity. The test is performed over a frequency range where the VSWR is approximately 1.25:1 for a properly operating probe. Electrical damage is indicated by any large decrease in return loss (increase in VSWR) as specified in the test.

4-3. Probes that fail this test, although damaged, may still detect electromagnetic radiation. In this case, the antenna factors listed on the unit are no longer valid and the circuitry no longer rejects electric field coupling. Recalibration of the probe's antenna factors is not possible.

**4-4. Return Loss Measurement Test**

Description

This test measures the return loss of the 11940C over a frequency range of 30 MHz to 80 MHz. The 8750A Storage-Normalizer is optional and increases the ease of reading return loss measurements. Any equipment that satisfies the following critical specifications for the test setup may be substituted for the recommended equipment:

Frequency Range ..... 200 MHz  
Test Port Match ..... >22 dB Return Loss

Equipment

Network Analyzer ..... HP 8754A  
Transmission/Reflection Test Set ..... HP 8502A  
Storage-Normalizer (Optional) ..... HP 8750A

Adapters:

Type N (m) to SMA (f) ..... HP 1250-1250  
Type SMA (m) to SMA (m) ..... HP 1250-1159  
Type SMA (f) Coaxial Short ..... HP 0960-0054

Cables:

RF Cable Kit for HP 8502A ..... HP 11851A

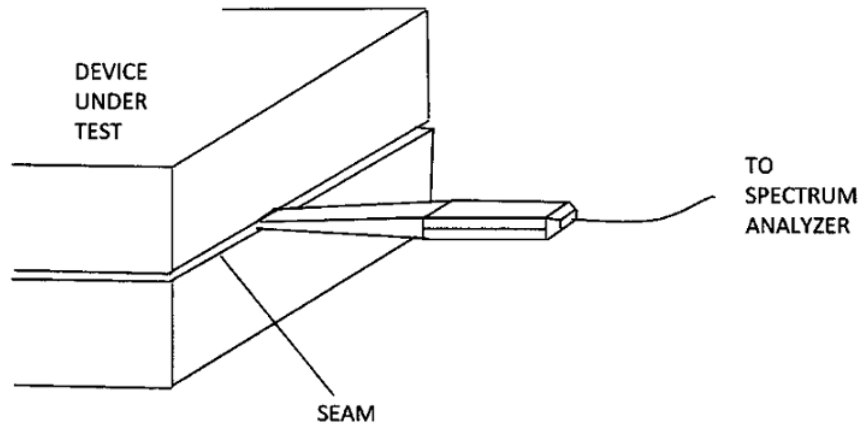


Figure 7. Testing an Enclosure Seam

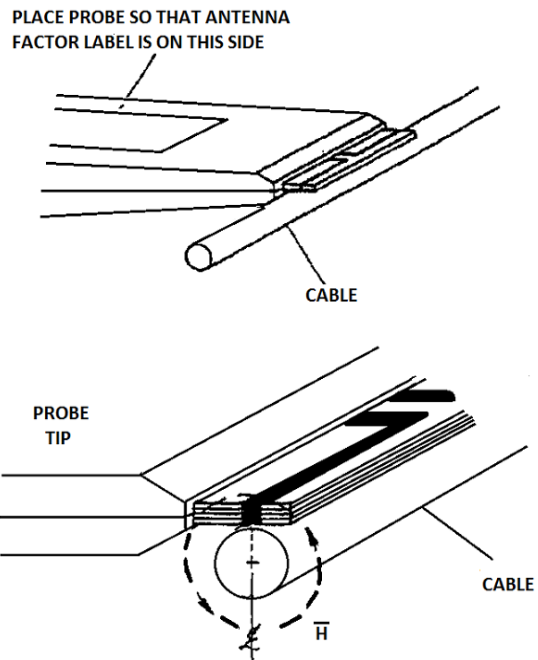


Figure 8. Testing a Coaxial Cable

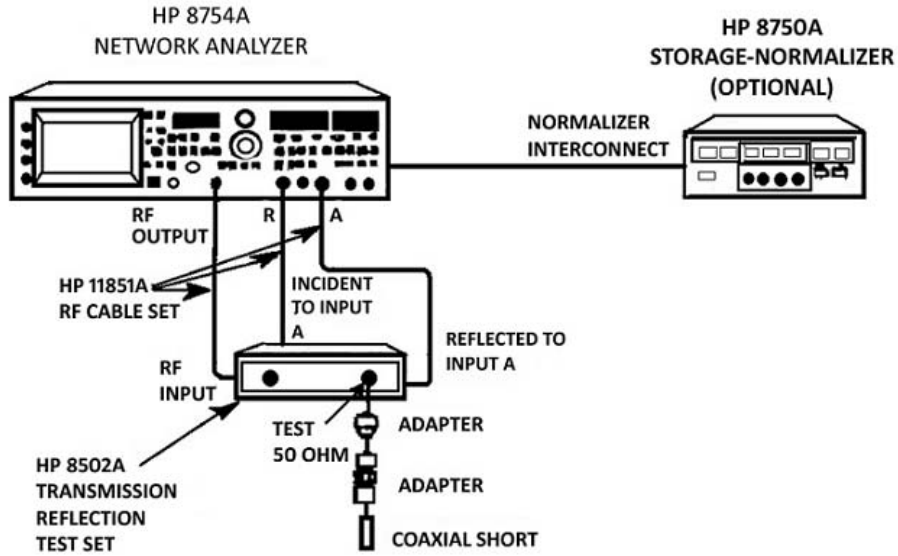


Figure 9. Return Loss Test Setup

Procedure

1. Connect the equipment as shown in Figure 9. Allow the HP 8754A 30 minutes of warm-up time.
2. If an HP 8750A Storage-Normalizer is used, adjust the normalizer's gain and position controls for the proper display on the network analyzer. Refer to the HP 8750A Operation and Service Manual for the adjustment procedure.
3. Set the HP 8754A controls as follows:

```

CH 1 REF POSITION .....ON
POLAR CENTER .....OFF
START ..... ON
TUNING ..... 30 MHz
SWEEP WIDTH ..... 50 MHz
SWEEP .....AUTO FAST
OUTPUT ..... +10 dBm
EXT FREQUENCY DOUBLER .....OFF

Channel 1
A/R ..... ON
10 dB/DIV .....ON
REFERENCE .....-00 dB
POLAR A/R ..... OFF

Channel 2 .....OFF
    
```



4. Set the HP 8502A Input Attenuation knob to 0 dB.
5. Adjust the HP 8754A trace to the top graticule line using the CH 1 REFERENCE POSITION knob. Turn the CH 1 REFERENCE POSITION off.
6. On the HP 8754A, turn on the CH 1 REFERENCE OFFSET. Adjust the trace, reference line, to the top CRT graticule using the REFERENCE OFFSET knob. The HP 8754A is now calibrated for making return loss measurements relative to the short.
7. If an HP 8750A Storage Normalizer is used, press the following keys on the HP 8750A: [CH 1], [INPUT], [STORE INPUT], and [INPUT-MEM]. The displayed reference line will shift to the middle of the screen. Errors in the reflection test set will now be normalized.
8. Remove the SMA Coaxial Short and replace it with the Cokeva 11940C probe. The displayed trace should be 16 dB or more below the reference line at all frequencies. If the trace is less than 16 dB below the reference line, the probe fails the test.

#### 5-1. SMA ROTARY JOINT INSTALLATION PROCEDURE

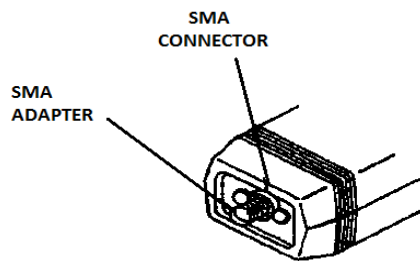


Figure 10. SMA ADAPTER LOCATION

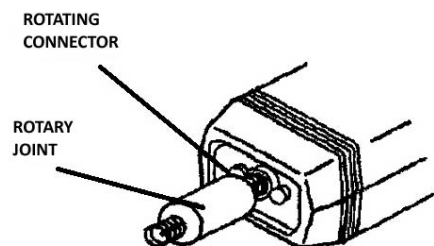


Figure 11. RF Rotary Joint Mounted on Probe

1. Use a 7/32" wrench to remove the old SMA Adapter (see Figure 10). Turn the adapter counterclockwise as viewed looking at the rear of the probe.
2. The SMA Rotary Joint has one SMA connector located at each end. One connector rotates with respect to the body of the Rotary Joint. The other connector is fixed to the body. Cover two or three end threads of the fixed end connector with a small amount of Loctite 222®.
3. Screw the rotating end of the Rotary Joint clockwise onto the probe's SMA Connector (see Figure 11).
4. Using a 9/32" torque wrench, tighten the Rotary Joint to 24 inch-pounds.
5. When attaching a cable to the Rotary Joint, hold the Rotary Joint by hand to keep the connector from turning.

For Cokeva Internal Reference Only

Cokeva Part Number CK-11940-90007

Printed in USA

January 2013