

## Errata

**Title & Document Type:** 84812A / 84813A 84814A / 84815A Peak Power Sensor Operating and Service Manual

**Manual Part Number:** 5960-7081

**Revision Date:** December 1993

### About this Manual

We've added this manual to the Agilent website in an effort to help you support your product. This manual provides the best information we could find. It may be incomplete or contain dated information, and the scan quality may not be ideal. If we find a better copy in the future, we will add it to the Agilent website.

### HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, life sciences, and chemical analysis businesses are now part of Agilent Technologies. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A. We have made no changes to this manual copy.

### Support for Your Product

Agilent no longer sells or supports this product. You will find any other available product information on the Agilent Test & Measurement website:

[www.agilent.com](http://www.agilent.com)

Search for the model number of this product, and the resulting product page will guide you to any available information. Our service centers may be able to perform calibration if no repair parts are needed, but no other support from Agilent is available.



**Agilent Technologies**



---

# Operating and Service Manual

## HP 84812A/13A/14A/15A Peak Power Sensor

### SERIAL NUMBERS

Affixed to the instrument is a serial number label. The serial number is in the form: 0000A00000. The first four digits and the letter are the serial number prefix. The last five digits are the suffix. The prefix is the same for identical instruments; it changes only when a configuration change is made to the instrument. The suffix, however, is assigned sequentially and is different for each instrument.

This manual applies to instruments with following serial number prefixes:

HP 84812A: 3212A and above

HP 84813A: 3203A and above

HP 84814A: 3205A and above

HP 84815A: 3227A and above



**HEWLETT  
PACKARD**

OTS LIBRARY

HP Part No. 5960-7081

Printed in USA December 1993

**OTS LIBRARY**



2400012168

**Notice.** The information contained in this document is subject to change without notice. Hewlett-Packard makes no warranty of any kind with regard to this material, including but not limited to, the implied warranties of merchantability and fitness for a particular purpose.

Hewlett-Packard shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material.

© Copyright Hewlett-Packard Company 1993

All Rights Reserved. Reproduction, adaptation, or translation without prior written permission is prohibited, except as allowed under the copyright laws.

1400 Fountaingrove Parkway, Santa Rosa CA,  
95403-1799, USA

---

## Warranty

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company 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 a service facility designated by Hewlett-Packard. Buyer shall prepay shipping charges to Hewlett-Packard and Hewlett-Packard shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to Hewlett-Packard from another country. Hewlett-Packard warrants that its software and firmware designated by Hewlett-Packard for use with an instrument will execute its programming instructions when properly installed on that instrument. Hewlett-Packard 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 by Buyer, 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. HEWLETT-PACKARD 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. HEWLETT-PACKARD SHALL NOT BE LIABLE

FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

---

## Assistance

*Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products. For any assistance, contact your nearest Hewlett-Packard Sales and Service Office.*

---

## Certification

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.

---

## How to Use This Manual

**This manual uses the following conventions:**

**Front-Panel Key**

This represents a key physically located on instrumentation.

**Softkey**

This indicates a "softkey," a key whose label is determined by the instrument's firmware.

**Caution**

---

*Caution* denotes a hazard. It calls attention to a procedure that, 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.

---

**Warning**

---

***Warning* 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* note until the indicated conditions are fully understood and met.**

---

## **Regulatory Information**

### **Herstellerbescheinigung**

Hiermit wird bescheinigt, daß dieses Gerät/System in Übereinstimmung mit den Bestimmungen von Postverfügung 1046/84 funkentstört ist.

Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerätes/System angezeigt und die Berechtigung zur Überprüfung der Serie auf Einhaltung der Bestimmungen eingeräumt.

#### **Zusatzinformation für Meß- und Testgeräte:**

Werden Meß- und Testgeräte mit ungeschirmten Kabeln und/oder in offenen Meßaufbauten verwendet so ist vom Betreiber sicherzustellen, daß die Funkentstörbedingungen unter Betriebsbedingungen an seiner Grundstücksgrenze eingehalten werden.

### **Manufacturer's Declaration**

This is to certify that this equipment is in accordance with the Radio Interference Requirements of Directive FTZ 1046/1984. The German Bundespost was notified that this equipment was put into circulation, and has been granted the right to check the equipment type for compliance with these requirements.

**Note:** If test and measurement equipment is operated with unshielded cables and/or used for measurements in open setups, the user must ensure that under these operating conditions, the radio frequency interference limits are met at the border of his premises.



# Contents

---

<b>1. About this Book</b>	
<b>2. About the Sensor</b>	
Sensor Description . . . . .	2-1
Options . . . . .	2-2
Adapters Available . . . . .	2-2
Specifications . . . . .	2-3
<b>3. Inspection of the Sensor</b>	
Inspecting the Sensor . . . . .	3-1
Visual Inspection . . . . .	3-1
Operation Check . . . . .	3-2
Sensor Check . . . . .	3-2
Sensor Check with Calibrated Reference . . . . .	3-3
Shipping the Sensor . . . . .	3-6
Storing the Sensor . . . . .	3-6
<b>4. Operating the Sensor</b>	
Operating Environment . . . . .	4-1
Operating Precautions . . . . .	4-2
Measuring Power and Pulse Parameters . . . . .	4-2
<b>5. Service</b>	
Removing the Covers . . . . .	5-2
Anti-Static Work Station . . . . .	5-4
Reducing Damage Caused by ESD . . . . .	5-4
PC Board Assemblies and Electronic Components . . . . .	5-4
Test Equipment . . . . .	5-5

Static-Safe Accessories . . . . .	5-6
More Static-Safe Accessories . . . . .	5-7
Cable Replacement . . . . .	5-8
Equipment . . . . .	5-8
Procedure . . . . .	5-8

**6. Calibration**

. . . . .	6-1
Introduction . . . . .	6-1
Preparing for Calibration . . . . .	6-4
Calibration Outline . . . . .	6-5
Read Peak Power Sensor Calibration	
Frequencies . . . . .	6-6
Procedure . . . . .	6-7
Measure Reflection Coefficient . . . . .	6-9
Test Equipment: . . . . .	6-9
Description . . . . .	6-10
Procedure . . . . .	6-10
Measure Power Levels . . . . .	6-14
Description . . . . .	6-14
Equipment . . . . .	6-15
Preparation . . . . .	6-15
Procedure . . . . .	6-16
Calculate Transfer Cal Factor Percentage	6-18
Calculate Cf . . . . .	6-18
Calculating Cf Example . . . . .	6-19
Calculating CF Program . . . . .	6-23
Download Transfer Cal Factors . . . . .	6-24
Power Variation Testing . . . . .	6-26
Procedure . . . . .	6-27

## Figures

---

2-1. The Peak Power Sensors . . . . .	2-1
3-1. SENSOR CHECK Source Check Setup	3-3
5-1. Removing the Sensor Covers . . . . .	5-2
5-2. Static-Safe Workstation . . . . .	5-5
5-3. Cable Replacement . . . . .	5-11
6-1. Controller Setup . . . . .	6-6
6-2. Measure Reflection Coefficient- Equipment Setup . . . . .	6-9
6-3. Power Level Measurement Setup . . . .	6-14
6-4. Power Level Variation Test . . . . .	6-26

## Tables

---

2-1. Peak Power Sensors Specifications . . .	2-4
5-1. Static-Safe Accessories . . . . .	5-6
5-2. More Static-Safe Accessories . . . . .	5-7
5-3. Replaceable Parts . . . . .	5-10
5-4. Exchange Sensor modules . . . . .	5-12
6-1. Recommended Calibration Test Equipment . . . . .	6-2
6-2. Calibration Factor at Calibration Frequencies Data . . . . .	6-30
6-3. Non-Calibration Frequency Data . . . .	6-30
6-4. 100 $\mu$ W Power Level Data . . . . .	6-31
6-5. 2 mW to 20 mW Power Level Data . . .	6-31
6-6. Hewlett-Packard Sales and Service Offices . . . . .	6-32

## About this Book

---

The *HP 84812A, 84813A, 84814A, 84815A Operating and Service Manual* contains information about the use, maintenance, and repair of the HP 84812A, 84813A, 84814A, and 84815A peak power sensors. In this manual, the words “sensor”, “peak sensor”, and “peak power sensor” refer to any of the HP 84812A, 84813A, 84814A, and 84815A peak power sensors.

- Chapter 1, About this Book, contains:
  - How to use this book to find information about the task you are performing
- Chapter 2, About the Sensor, contains:
  - Sensor Description
  - Options
  - Adapters Available
  - Specifications
- Chapter 3, Inspection of the Sensor, contains:
  - Visual Inspection
  - Operation Check
  - Sensor Check
  - Sensor Check with Calibrated Reference
  - Shipping the Sensor
  - Storing the Sensor
- Chapter 4, Operating the Sensor, contains:
  - Operating Instructions
  - Operating Environment
  - Operating Precautions
  - Measuring Power and Pulse Parameters

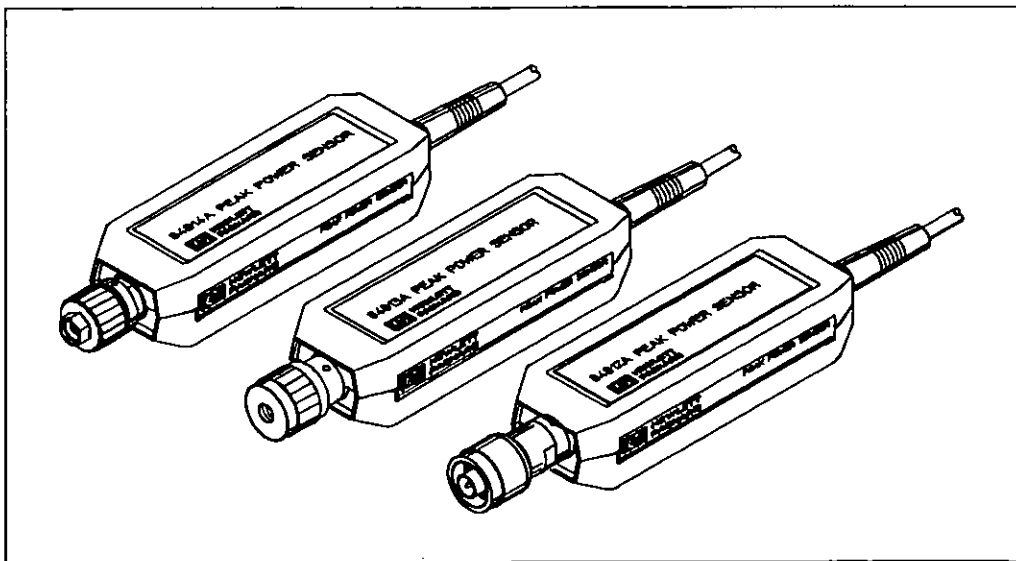
- Chapter 5, Service, contains:
  - What to do if you suspect your sensor is defective
  - Removing the Covers
  - Anti-Static Work Station
  - Cable Replacement
  - Replaceable Parts List
  - List of Exchange Sensor modules
- Chapter 6, Calibration, containing:
  - List of Calibration Test Equipment
  - Read Peak Power Sensor Calibration Frequencies
  - Measure Reflection Coefficient
  - Measure Power Levels
  - Calculate Transfer Cal Factor Percentage
  - Download Transfer Cal Factors
  - Power Variation Testing

## About the Sensor

---

### Sensor Description

The HP 84812A, 84813A, 84814A, and 84815A peak power sensors are specifically designed to be used with the HP 899X peak power analyzers. Together, any of the four sensors and the analyzer comprise the power measurement system which senses and displays envelope power in the range of  $-32$  to  $+20$  dBm.



**Figure 2-1. The Peak Power Sensors**

Figure 2-1 shows the peak power sensors.

Balanced Planar Doped Barrier (PDB) diodes are the sensing elements of the peak power sensors. They

provide a specified dynamic range of  $-32$  to  $+20$  dBm (usable to  $-40$  dBm). The peak power sensors also contain a wideband, high dynamic range sensor amplifier which allows for very fast system risetime. Excellent SWR is provided by the integrated matching network and diodes.

Peak power sensor calibration data is automatically loaded from the sensor EEPROM to the HP 899X peak power analyzer. Thus, the user is not required to perform a manual sensor calibration.

---

## Options

The options listed here apply to the HP 84812A, 84813A, 84814A and 84815A peak power sensors.

**Option 001** provides a 6.1 metre (20 ft) sensor cable.

**Option 1BN** provides a MIL STANDARD 45662A calibration certificate with your sensor.

---

## Adapters Available

Type-N (m) to 3.5 mm (f):

HP Part No. 08485-60005 (Recommended to 1 GHz.)

HP Part No. 1250-1744

Type-N (m) to 2.4 mm (f):

HP Part No. 08487-60001 (Recommended to 1 GHz.)

HP Part No. 11903D

---

## Specifications

Specifications are those parameters against which the peak power sensors can be tested. General Characteristics are parameters included as useful information. Table 2-1 lists the specifications and general characteristics of the sensors.



Table 2-1. Peak Power Sensors Specifications

Specifications	
Frequency Range 84812A:	500 MHz to 18 GHz
Frequency Range 84813A:	500 MHz to 26.5 GHz
Frequency Range 84814A:	500 MHz to 40 GHz
Frequency Range 84815A:	50 MHz to 18 GHz* ( <i>typical, 20 MHz to 18 GHz</i> )
Dynamic Range:	-32 to +20 dBm (Usable to -40 dBm.)
Sensor Calibration	< 4 GHz: $\pm 3.6\%$
RSS Uncertainty:	< 12 GHz: $\pm 3.9\%$
	< 18 GHz: $\pm 4.3\%$
	< 26.5 GHz: $\pm 5.6\%$
	< 40 GHz: $\pm 6.7\%$
Input SWR, max (Reflection Coefficient):	84812A/13A/14A 500 MHz to 18 GHz: 1.25 (0.11) 18 GHz to 26.5 GHz: 1.35 (0.15) 26.5 GHz to 40 GHz: 1.60 (0.23)
	84815A <i>20 MHz to 50 MHz: 1.2 (0.09), typical</i> 50 MHz to 6 GHz: 1.20 (0.09) 6 GHz to 18 GHz: 1.30 (0.13)
Rise/Falltime:	Specifications for sensors are found in the HP 899X Operating Manual.
Maximum Power Input:	1 W peak power for 1 $\mu$ s, not to exceed 200 mW (CW)
Operating Temperature:	0°C to +55°C
* Below 50 MHz the carrier feedthrough starts to be noticeable due to decreasing video filtering. This effect can be eliminated by averaging except for the statistical functions (PDF and CDF) as used with the HP 8992A.	

Table 2-1. Peak Power Sensors Specifications (continued)

<b>General Characteristics</b>	
<b>Acoustic Noise Emissions:</b>	No Fan Installed
<b>Geraeuschemission:</b>	Kein Ventilator Eingebaut
<b>Connector HP 84812A/15A:</b>	Type-N Male
<b>Connector HP 84813A:</b>	APC-3.5 mm Male
<b>Connector HP 84814A:</b>	2.4 mm Male
<b>Sensor Cable Length:</b>	1.5 M (5 ft)
<b>Option 001:</b>	6.1 M (20 ft)
<b>Calibration Interval:</b>	18 months
<b>Parameters Corrected for:</b>	Frequency, Temperature, and Power Non-linearity.
<b>Dimensions HP 84812A/15A:</b>	27mm H, 37mm W, 137mm L (1.05" x 1.45" x 5.4")
<b>Dimensions HP 84813A:</b>	27mm H, 37mm W, 127mm L (1.05" x 1.45" x 5.0")
<b>Dimensions HP 84814A:</b>	27mm H, 37mm W, 127mm L (1.05" x 1.45" x 5.0")
<b>Weight:</b>	Net: 0.35 kg (0.8 lb); Shipping: 1 kg (2 lb)
<b>Option 001:</b>	Net: 0.8 kg (1.5 lb); Shipping: 1.5 kg (3 lb)

## Inspection of the Sensor

---

This chapter describes how to inspect your peak power sensor prior to use.

1. The procedure Operation Check should be performed at any time you need to verify sensor operation.
2. Follow the procedure Shipping the Sensor if the sensor fails Inspection of the Sensor.
3. Follow the procedure Storing The Sensor when you intend to store the sensor for any length of time.

---

### Inspecting the Sensor

Inspection of the sensor includes a Visual Inspection and an Operation Check.

#### Visual Inspection

1. Inspect the shipping container for damage.

If the shipping container or packaging material is damaged, keep it until the contents of the shipment are checked mechanically and electrically.

2. Inspect the sensor for mechanical damage.

If there is mechanical damage to the sensor, notify the nearest Hewlett-Packard Sales and Service Office listed inside the back cover of this manual.

Keep the damaged shipping materials (if any) for inspection by the carrier and a Hewlett-Packard representative.

## Operation Check

This operation check is intended to determine if the sensor is in operating condition, *not* to verify specifications. The vertical and delay cal procedures must be performed on the HP 899X first.

In order to pass the operation check the sensor should:

- Be attached to a Hewlett-Packard peak power analyzer.
- Autoscale and measure the power level of the analyzer SENSOR CHECK source.

## Sensor Check

1. Connect the peak power sensor cable to Channel 1 input on the peak power analyzer.
2. Connect the peak power sensor connector to the analyzer SENSOR CHECK source.
3. Preset the analyzer; press: **RECALL**; then **CLEAR**.
4. Press **AUTOSCALE**.
5. Press:  
**BLUE** (shift) key.  
**TOP**  
**1**
6. The reading should appear in the lower portion of the analyzer display. To pass this check the sensor should read between 8.9 mW (+9.5 dBm) and 11.2 mW (+10.5 dBm).
7. If the sensor passes, stop. End of operation check.

## Note

---

If you do not receive a reading in this range (10 dBm  $\pm$ 0.5 dB) the sensor or the analyzer SENSOR CHECK source is at fault. Perform the Sensor Check with Calibrated Reference procedure below to find out if the sensor is faulty.

---

### Sensor Check with Calibrated Reference

This check verifies that the HP 899X peak power analyzer SENSOR CHECK source is providing a signal and that the peak power sensor is sensing the signal correctly. To do this, an average power meter reading of the HP 899X peak power analyzer SENSOR CHECK source signal is compared to the peak power sensor reading of the same source.

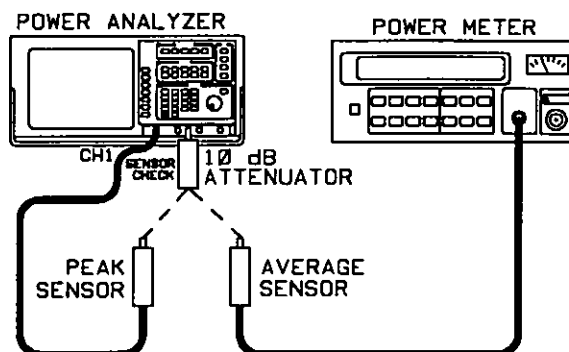


Figure 3-1. SENSOR CHECK Source Check Setup

Equipment	Recommended
Power Meter	HP 437B
Average Power Sensor	HP 8481A
10 dB Attenuator:	HP 8491A Opt 10
Adapters:	As needed.

### Note

All equipment must be warmed up for at least one hour.

1. Refer to the equipment table above and Figure 3-1. Attach the 10 dB attenuator to the analyzer SENSOR CHECK source.

2. Change the analyzer SENSOR CHECK source to CW mode:

Preset the analyzer; press: **RECALL**; then **CLEAR**.  
Press **UTIL**.

Press the **check source** softkey until **CW** is highlighted.

3. Zero and calibrate the average power sensor.
4. On the average power meter enter the 1.0 GHz cal factor.
5. Connect the average power sensor to the analyzer SENSOR CHECK source and take a reading in dBm. The reading should be approximately 0 dBm.

Average Sensor \_\_\_\_\_ dBm  
Reading

6. Disconnect the average sensor from the analyzer SENSOR CHECK source.
7. Connect the peak power sensor to the analyzer SENSOR CHECK source.
8. Press **AUTOSCALE**.
9. Press:

**BLUE KEY**

**AVG**

**1**

10. Display the analyzer power level reading in dBm:

Press **DISPLAY**

Toggle the **power display** softkey until **log** is highlighted.

11. Take a reading from the lower portion of the analyzer screen.

Peak Sensor \_\_\_\_\_ dBm  
Reading

12. Compare the average sensor reading to the peak sensor reading. The peak power sensor is operating if the reading is within  $\pm 0.5$  dB of the average sensor reading.
13. If the peak sensor does not pass, send it back to Hewlett-Packard. See Shipping the Sensor below.

---

**Note**

In order to calibrate the peak power sensor, follow the test procedures located in the Calibration section, Chapter 6, Service. If the sensor does not pass the calibration, call your nearest Hewlett-Packard Sales and Service Office listed inside the back cover of this manual.

---

**Note**

The performance test for the rise time is in the HP 899X manual.

---

---

## Shipping the Sensor

1. Contact your nearest Hewlett-Packard Sales and Service Office listed inside the back cover of this manual to obtain shipping materials identical to those used in factory packaging if you do not have adequate shipping materials.
2. Attach a tag to the sensor indicating:
  - a. the type of service required
  - b. your return address
  - c. the sensor model number
  - d. the sensor serial number
3. Mark the container FRAGILE to ensure careful handling.
4. Mail the package to your nearest Hewlett-Packard Sales and Service Office listed inside the back cover of this manual.

### Note

---

In any correspondence, refer to the sensor by model number and serial number.

---

---

## Storing the Sensor

1. Store the peak power sensor in a clean, dry environment.
2. Store the sensor within the following environmental conditions:

Temperature	-40 to +70°C
Relative humidity	< 95% @ < 40°C
Altitude	< 7,600 m (25,000 ft).



## Operating the Sensor

---

In order to use the peak power sensor:

1. Set up the proper Operating Environment.
2. Be aware of sensor Operating Precautions.
3. Follow the procedure Measuring Power and Pulse Parameters with your sensor and the HP 899X peak power analyzer.

---

**Note**

To prolong the life of the sensor, take care of your connectors. Connecting the peak power sensor to worn or dirty connectors will hasten the degradation of the peak power sensor connector.

---

---

**Operating Environment**

The operating environment for the power sensor is as follows:

Temperature	0° to 55°C
Relative humidity	< 95% @ < 40°C
Altitude	< 4,572 m (15,000 ft).

---

## Operating Precautions

### Caution

If the following energy and power levels are exceeded, the peak power sensor *will* be damaged.

Maximum Average Power: 200 mW  
Maximum Peak Power: 1 W for 1 $\mu$ s

Never apply torque to the body of the peak power sensor. When making connections, turn only the knurled portion of the connecting nut. Apply no more than 8 in·lbs (90 N·cm) torque to the hex connector nut on the HP 84814A.

Avoid touching the center pin in the peak power sensor connector. Touching the center pin could damage the sensor through Electro-Static Discharge (ESD).

Clean the sensor connector only in a static safe workstation like the one described in chapter 5. First use a blast of compressed air. Clean the connector surfaces with a cotton swab saturated with isopropyl alcohol (use no other solvents) then, if needed, a wooden toothpick (use no metal implements).

---

---

## Measuring Power and Pulse Parameters

### To operate the power sensor

1. Set up the HP 899X peak power analyzer for power measurement as described in the *HP 899X Peak Power Analyzer Operating Manual*.
2. Connect the peak power sensor cable to Ch 1 or Ch 4 of the HP 899X peak power analyzer. (Channel 4 is not operable in the HP 899X Option 001).

3. Refer to the Operating Precautions before connecting the peak power sensor input to a RF/microwave signal to be measured.

**Note**

---

The peak power sensor calibration data is located inside the EEPROM of the sensor and contains information about frequency and temperature over many power levels. Since the calibration data is automatically transferred to the HP 899X peak power analyzer during a power measurement, the user does not need to perform a manual sensor calibration.

**The peak power sensor:**

- a. Automatically adjusts for temperature variations between 0° and 55 °C during power measurement. (This applies only to the sensor, refer to the analyzer operating manual for analyzer operating environment.)
- b. Automatically interpolates calibration factor data for frequencies between those frequencies at which the sensor is calibrated. This means that after you enter your frequency of interest into the analyzer, there is no further need to enter calibration factor data.

- 
4. Refer to the *HP 899X Peak Power Analyzer Operating Manual* for measurement procedures.

**Note**

---

All HP 899X firmware versions prior to and including March 1992 require a greater than 100 MHz change in the carrier frequency before new power calibration tables are rebuilt and used. This may cause inaccurate power readings when using the HP 84515A sensor below 1 GHz. A way to ensure the most accurate power measurements at frequencies below 1 GHz is to change the carrier frequency to 18 GHz, then change the carrier frequency to the desired value. This forces the HP 899X to build

new power calibration tables at the carrier frequency you are measuring.

To check the firmware version on the HP 899X, press **UTIL** **Show Status**. The firmware version will appear on the HP 899X display.

---

**Note**

Your peak power sensor should be calibrated after 18 months of normal use. See chapter 6, Service, in this manual.

---

## Service

---

This chapter details what to do if you suspect your peak power sensor is defective.

**Note**

---

Check your warranty. Opening the power sensor may void the warranty.

---

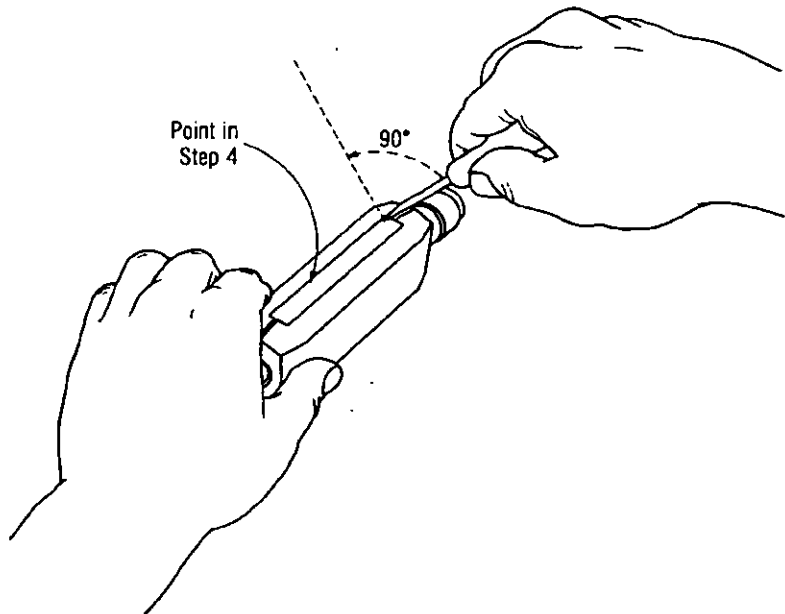
1. First determine if your sensor is defective.
  - a. Perform the Inspection of the Sensor procedure described in chapter 3.
  - b. If your sensor fails, it is defective.
2. Determine your sensor service alternative.
  - a. Call your nearest HP Sales and Service Office listed inside the back cover of this manual.
  - b. Depending on the state of your warranty, the office will advise you as to the service options available to you.

**Exchange Sensor Module**

The service center may advise you to order an exchange sensor module. Each exchange sensor module is fully calibrated and restored to be functionally the same as a new unit except for plastic covers. See *Removing the Covers*, on the next page. When your exchange sensor module arrives, replace your old plastic covers (containing your sensor serial number) on the new unit. Refer to Table 5-4 to order an exchange sensor module.

## Removing the Covers

Your sensor serial number is located on a label attached to one of the covers. If you order a restored assembly listed in Table 5-4 you may be advised to save your covers and place them on your new restored assembly. Perform the procedure exactly as described to minimize damage to the connector covers.



**Figure 5-1. Removing the Sensor Covers**

### Caution

The sensor plastic half shell covers are easily damaged. Expect to see *at least* some cosmetic damage to the covers from the removal process. If you wish to replace your plastic half shell covers and labels, see Table 5-3.

**Equipment:**

A small flat blade screwdriver with a blade width no greater than 3.5 mm (1/8 inch).

**Procedure.**

1. Place the sensor so its narrow side is on a flat surface. Position it so that the connector is facing away from you. Refer to Figure 5-1.
2. Hold the sides of the sensor near the cable end. Insert the screwdriver at a 45° angle as shown in Figure 5-1. Make sure the screwdriver is inserted as far forward on the sensor as possible.
3. Rotate the screw driver about 90° as shown, until the covers snap apart.
4. Repeat steps 2 and 3, inserting the screwdriver approximately 2/3 of the way toward the cable end of the sensor, at the point shown in Figure 5-1.
5. Separate the plastic shell halves. If the cover does not separate easily, repeat steps 2, 3, and 4 on the other side of the sensor.
6. Attach the covers to the exchange sensor module by snapping the two shells together.

---

## **Anti-Static Work Station**

Electrostatic discharge (ESD) can damage or destroy electronic components. Therefore, all work performed on assemblies consisting of electronic components should be done at a static-safe workstation.

Figure 5-2 shows an example of a static-safe workstation using two types of ESD protection: 1) conductive table mat and wrist strap combination, and 2) conductive floor mat and heel strap combination. These methods may be used together or separately. (A list of static-safe accessories and their part numbers is given on the following pages.)

## **Reducing Damage Caused by ESD**

Below are suggestions that may help reduce ESD damage that occurs during testing and servicing instruments.

## **PC Board Assemblies and Electronic Components**

Handle these items at a static-safe workstation.

Store or transport these items in static-shielding containers.



**Test Equipment**

Before connecting any coaxial cable to an instrument connector for the first time each day, momentarily ground the center and outer conductors of the cable.

Personnel should be grounded with a resistor-isolated wrist strap before touching the center pin of any connector and before removing any assembly from the instrument.

Be sure that all instruments are properly earth-grounded to prevent build-up of static charge.

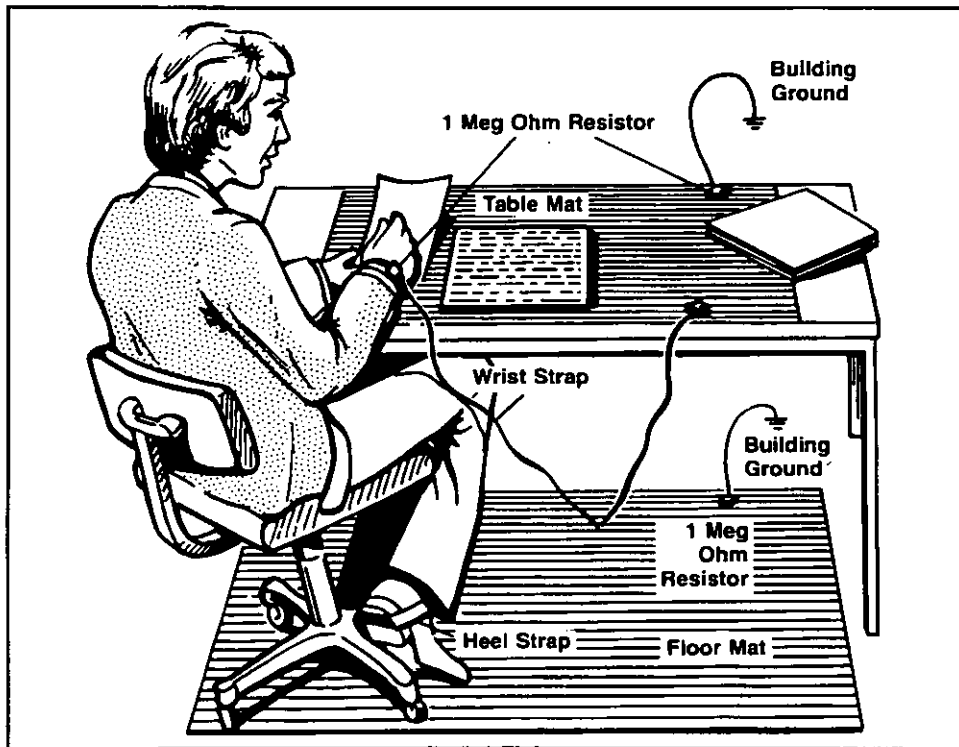


Figure 5-2. Static-Safe Workstation

**Static-Safe  
Accessories**

Table 5-1 is a list of static-safe accessories that may be obtained from any Hewlett-Packard office by using the HP part numbers listed.

**Table 5-1. Static-Safe Accessories**

HP Part Number	Description
9300-0797	3M <sup>TM</sup> static control mat .6m x 1.2m (2 x 4 ft) 4.6m (15 ft.) ground wire wrist strap and attachment cord
9300-0980	Wrist strap cord 1.5m (5 ft.)
9300-0985	Wrist strap (large)
9300-0986	Wrist strap (small)
9300-1169	ESD heel strap (reusable 6 to 12 months)
9300-0793	Shoe ground strap (one-time use only)

### More Static-Safe Accessories

The ESD accessories in Table 5-2 can be ordered from:

Hewlett-Packard Company  
Computer Supplies Operations  
1320 Kifer Road  
Sunnyvale, California 94086  
Phone: (408) 738-8858

**Table 5-2. More Static-Safe Accessories**

HP Part Number	Description
92175A	Black, hard-surface, static control mat, 1.2m x 1.5m (4 ft. x 5 ft.)
92175B	Brown, soft-surface, static control mat, 2.4m x 1.2m (8 ft. x 4 ft.)
92175C	Small, black, hard-surface, static control mat, 1.2m x 0.9m (4 ft. x 3 ft.)
92175T	Tabletop static control mat, 58 cm x 76 cm (23" x 30")
92176A	Anti-static carpet (natural color), 1.8m x 1.2m (6 ft. x 4 ft.)
92176C	Anti-static carpet (russet color), 1.8m x 1.2m (6 ft. x 4 ft.)
92176B	Anti-static carpet (natural color), 2.4m x 1.2m (8 ft. x 4 ft.)
92176D	Anti-static carpet (russet color), 2.4m x 1.2m (8 ft. x 4 ft.)

## Cable Replacement

This procedure describes how to replace the peak sensor cable.

### Caution

Open the peak power sensor *only* in a static free environment or damage *will* occur.

Disconnect the sensor from the HP 899X before beginning the replacement procedure.

Replacing the cable *will* invalidate MIL-STANDARD 45662A calibration. If you wish to retain your MIL-STANDARD 45662A calibration contact your nearest Hewlett-Packard Sales and Service Office.

Replace your cable with one of the same length to maintain sensor specifications. Do not replace a 5 foot cable with a 20 foot cable. Do not replace a 20 foot cable with a 5 foot cable.

### Equipment

Open End	7/16 in. (11.2 mm);
Torque wrench	25 in-lbs (282.5 N-cm)
Open End	SMC 15/64 in. (6 mm);
Torque wrench	4 in-lbs (45 N-cm)
Screwdriver	Small Posidrive

### Procedure

1. Perform this procedure only in an electrostatic discharge (ESD) free environment.
2. Disconnect the peak power sensor from the HP 899X peak power analyzer.
3. Remove the covers. See Figure 5-1 and Removing the Covers in this chapter.
4. Refer to Figure 5-3. Remove two screws ② from the sensor shield ④.
5. Slide the sensor shield ④ over the sensor cable and expose the sensor interior.

6. With your 15/64 in. wrench unscrew the SMC nut ⑥ from the PC board.
7. With your fingers pull the connector ⑦ free from the PC board.
8. With your 7/16 in. wrench unscrew the cable nut ⑧.
9. Pull the sensor shield ④ free of the cable.
10. Slide the sensor shield ④ over the new cable.
11. Tighten cable nut ⑧ to 25 in·lbs (282.5 N·cm).
12. Place a drop of "Blue Loctite™" (not shown) on the exposed threads of ⑧.
13. Place connector ⑦ on the PC board.
14. Tighten nut ⑥ to 4 in·lbs (45 N·cm).
15. Slide metal case over the unit and secure with screws ② and lockwashers ③.
16. Reinstall the covers.
17. Perform the operation check in Chapter 3, Inspection of the Sensor.

Table 5-3. Replaceable Parts

Item	CD	HP Part No.	Description
1	3	85025-40006	Plastic Half Body
2	8	0515-0972	Screw Mach M2.5
3	9	2190-0583	Washer LCK HLCL
4	7	84812-20027	Sensor Shield
5*	3	84812-60003	Standard Cable
*	4	84812-60004	Option 001 Cable
6	p/o Standard/Option 001 Cable Assembly. This part is not separately available.		
7	p/o Standard/Option 001 Cable Assembly. This part is not separately available.		
8	p/o Standard/Option 001 Cable Assembly. This part is not separately available.		
9	6	84812-80004	Serial Label
10	3	84812-80001	Information Label
11	5	84812-80003	ID Label
	4	84813-80001	ID Label
	5	84814-80001	ID Label
	8	84815-80003	ID Label
12	4	84812-80002	Caution Label
13	7	84812-80005	Mylar overlay
	6	0470-0231	Loctite
<p>* For cable replacement, check amplifier board number.            For amplifier board 84812-60002, order:            84812-60008 (STD CBL) or 84812-60009 (OPT 001 CBL)            For amplifier board 84812-60028, order:            84812-60003 (STD CBL) or 84812-60004 (OPT 001 CBL)</p>			

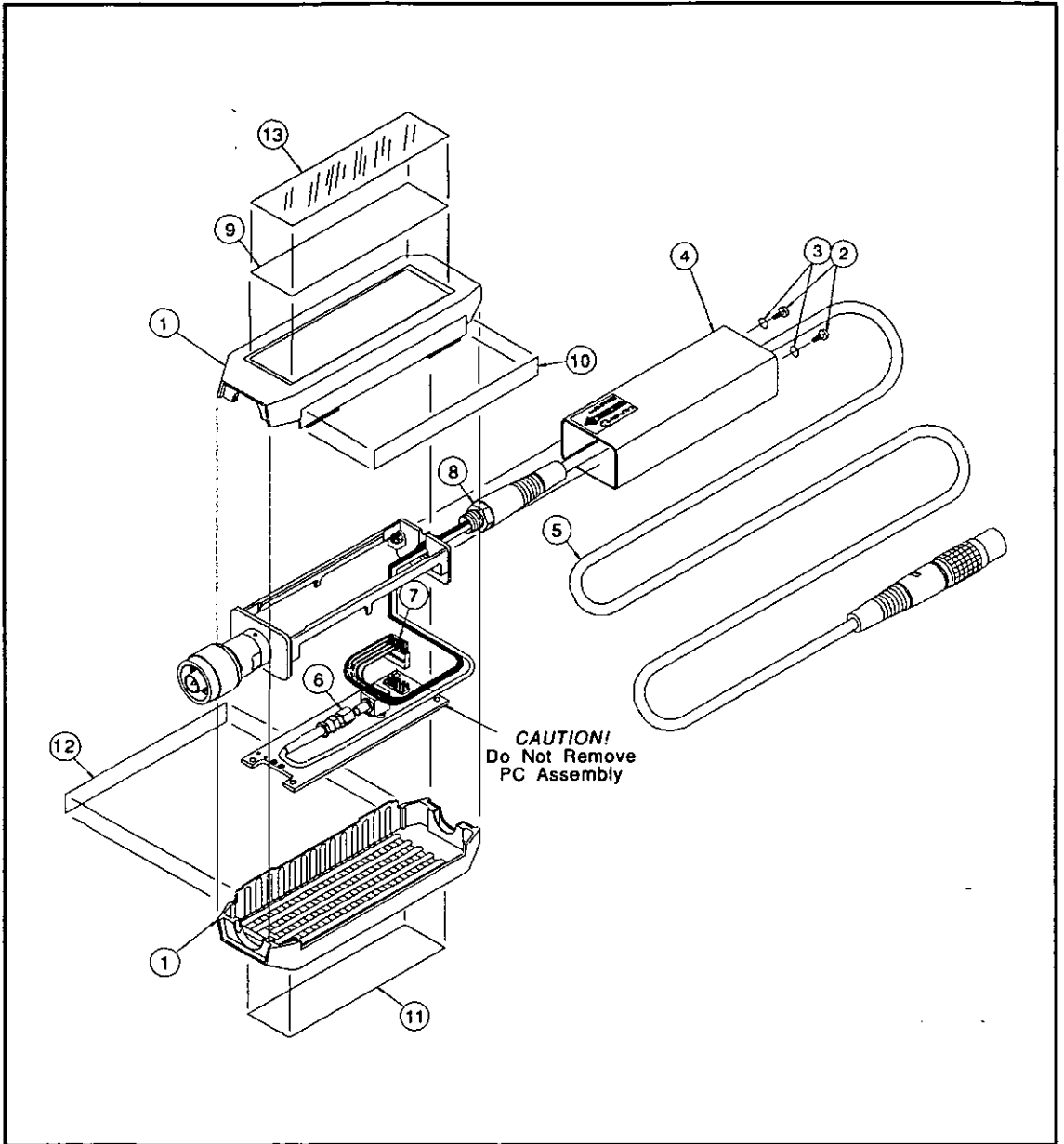


Figure 5-3. Cable Replacement

Table 5-4. Exchange Sensor modules

Model No.	Sensor with 5 ft cable	Sensor with 20 ft cable
HP 84812A	84812-69013	84812-69002
HP 84813A	84813-69014	84813-69003
HP 84814A	84814-69015	84814-69002
HP 84815A	84815-69003	84815-69004



## Calibration

---

### Introduction

After 18 months of normal use, your HP 84812A, 84813A, 84814A, or 84815A peak power sensor should be calibrated.

Before attempting calibration, make sure your sensor passes the operating check located in chapter 3, *Inspection of the Sensor*.

There are three ways you can calibrate your sensor:

- Perform this calibration procedure.
  - Refer to the list of required equipment in Table 6-1 to determine if you have the resources needed to calibrate your sensor.
- Replace your sensor with an exchange sensor module. The exchange sensor module is restored to original condition with a factory calibration. See Table 5-4 *Exchange Sensor Modules*.
- Send your sensor back to HP for a factory calibration.

If you choose to return your sensor to HP for calibration or replacement, call your nearest HP Sales and Service Office listed inside the back cover of this manual to get cost and time estimates.

If you choose to perform your own calibration, continue reading.

Table 6-1. Recommended Calibration Test Equipment

Instrument Type	Critical Specifications	Suggested Model
Peak Power Analyzer	No substitute	HP 899X
HP-IB Controller	Interface capabilities as defined by IEEE Compatibility Code (Std 488.2-1988): SH1, AH1, T5, L4, SR1, RL1, PP1, DC1, DT1, C0, and E2.	HP 9000 Series 200/300
Software	HP Basic Operating System	HP Basic 3.0 or greater
Network Analyzer System	50 MHz to 26.5 GHz 500 MHz to 40 GHz	HP 8510B HP 8510C
S Parameter Test Set	Compatible with frequency range of Network Analyzer	HP 8515A HP 8517A
Signal Generator	50 MHz to 18 GHz $\leq -50$ dBc harmonics and spurious signals  500 MHz to 40 GHz $\leq -50$ dBc harmonics and spurious signals	HP 83732A Option 1E1  HP 83640A
Power Splitter	Reflection RSS Uncertainty < 0.03 Standards Laboratory Calibration	
2.4 mm	(HP 84814A only)	HP 11760S K13
3.5 mm	(HP 84813A only)	HP 11760S K05
Type N	(HP 84812A/15A only)	HP 11760S K03
Average Power Meter	2 each. No substitute	HP 437B

Table 6-1. Recommended Calibration Test Equipment (continued)

Instrument Type	Critical Specifications	Suggested Model
Average Sensor	Power Range: 1 $\mu$ W to 100 mW	
2.4 mm	Compatible with HP 437B. (HP 84814A only) Freq. Range: 500 MHz to 40 GHz	HP 8487A
3.5 mm	Compatible with HP 437B. (HP 84813A only) Freq. Range: 500 MHz to 26.5 GHz	HP 8485A
Type-N	Compatible with HP 437B. (HP 84812A/15A only) Freq. Range: 50 MHz to 18 GHz	HP 8481A
Standardized Sensor	Standards Lab calibrated average sensor. Compatible with average power meter.	
2.4 mm	Max SWR at 50 MHz $\leq$ 1.15 (HP 84814A)	HP 8487A H84
3.5 mm	Max SWR at 50 MHz $\leq$ 1.15 (HP 84813A)	HP 8485A H84
Type N	Max SWR at 50 MHz $\leq$ 1.15 (HP 84812A)	HP 8481A H84
	Cal Factor Calibration Uncertainty (RSS): 0.05 — 4 GHz: $<\pm 1.57\%$ 4 — 12 GHz: $<\pm 1.89\%$ 12 — 18 GHz: $<\pm 2.22\%$ 18 — 26.5 GHz: $<\pm 2.50\%$ 26.5 — 40 GHz; $<\pm 3.40\%$	
	Reflection Coefficient Uncertainty (RSS): 0.05 — 4 GHz: $<0.014$ 4 — 12 GHz: $<0.015$ 12 — 18 GHz: $<0.02$ 18 — 26.5 GHz: $<0.029$ 26.5 — 40 GHz; $<0.025$	
Calibration Kit		
2.4 mm	HP 84814A (only)	HP 85056D
3.5 mm	HP 84813A (only)	HP 85052D
Type N	HP 84812A/15A (only)	HP 85054D

## Preparing for Calibration

Before beginning the procedure, the HP 899X should be on and warmed up for at least one hour. After the initial warm-up period, calibrate the analyzer by:

- Toggle the rear panel **CALIBRATOR** switch to the UNPROTECTED position.
- **UTIL** key
- **more** display softkey,
- **instr cal menu**
- Perform a vertical calibration

The peak power analyzer display will prompt you through the instrument calibration. After the peak power analyzer is calibrated, it is important that the peak power analyzer and sensor remain at the same environmental conditions (room temperature within 5°C) throughout the sensor calibration procedure.

**Calibration Outline**

If the sensor fails at any of the steps below, send the sensor back to HP for repair. *Do not attempt to repair the sensor yourself.*

**Note**

---

Check the peak power sensor warranty. If the peak sensor is under warranty, follow the procedure Returning the Sensor in chapter 3. If the sensor is not under warranty, an exchange sensor module is the recommended method of repair.

---

- Step 1. Use the controller to read the list of calibration frequencies.
  - Record the calibration frequencies in Table 6-2.
- Step 2. Use the HP 8510B/C to measure peak sensor reflection.
  - If the peak sensor reflection coefficient measurement fails to meet specifications, (see Table 2-1, Peak Power Sensors Specifications) then the sensor should not be calibrated and should be repaired.
- Step 3. Measure power levels at the calibration frequencies.
- Step 4. Calculate and record transfer cal factors.
- Step 5. Use the controller to download the transfer cal factors.
- Step 6. Test the sensor at different power levels.

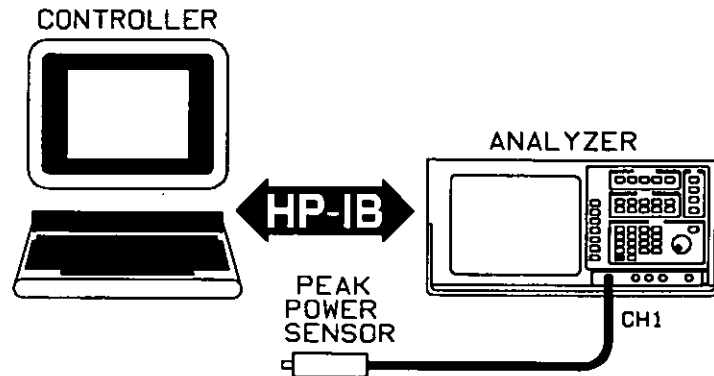
**Note**

---

The accuracy of the following calibration depends upon how accurately you make connections to the test equipment. See Application Note 326 *Principles of Microwave Connector Care* (HP Part Number 5954-1566), or *Microwave Connector Care* (HP Part Number 08510-90360).

---

## Read Peak Power Sensor Calibration Frequencies



**Figure 6-1. Controller Setup**

This is the first step of the calibration procedure. Use a controller via HP-IB to download from the sensor EEPROM the frequencies at which the sensor should be calibrated. These frequencies are known as calibration frequencies. Record the frequencies in a photocopy of Table 6-2 located near the end of this book.

### Note

If the calibration is to be successful, any previous "field calibration" should remain in an off condition during the entire procedure. See step "1" in this procedure.

The following program is written in HP Basic 3.0 using an HP 9000 Series 200/300 controller. Refer to the *HP 899X Programming Manual* for more detailed programming information.

**Caution**

*Do not* disconnect the sensor or cycle power while executing any read or write function to the peak power sensor EEPROM. If this happens, the peak power sensor EEPROM will be erased. This condition is not user repairable. The peak power sensor must be sent back to Hewlett-Packard for calibration.

**Procedure**

1. Turn off "field cal" under the "service menu". Press:
  - a. Press **UTIL**
  - b. Press **service menu**
  - c. Toggle **cal select** until **S** is highlighted
  - d. Toggle **field cal off/on** softkey until **off** is highlighted.
2. Connect the controller via HP-IB to the HP 899X analyzer.
3. Connect your peak power sensor to Channel 1 of the analyzer.
4. Type in, save, and RUN the following program to read the calibration frequencies.
5. The frequencies that will be displayed are the Calibration Frequencies. Record the frequencies in the "Freq." column of Table 6-2 located in the Data Tables section near the end of this book.

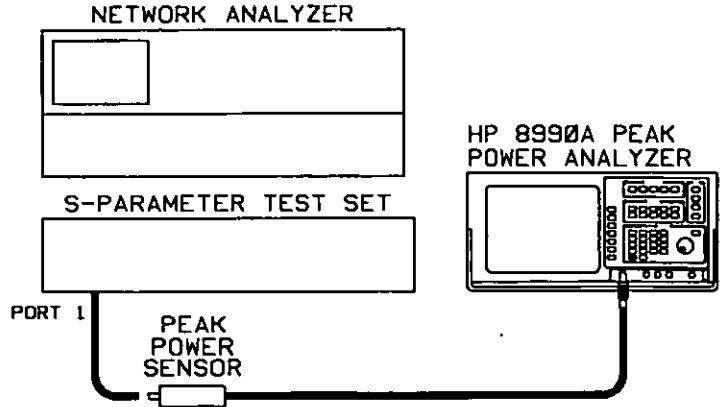
Peak Power Sensors

HP 84812/13/14A/15A

```
10 DIM Flist(50),A$[300]
20 ASSIGN @A TO 707
30 !
40 ! 707 is HP 899X default HP-IB Address
50 !
60 OUTPUT @A;":CAL:FIELD:POINTS? CHAN1"
70 !
80 ! Queries Sensor for number of calibration freq
90 !
100 ENTER @A;N
110 PRINT "CHAN1 #of field cal points: ";N
120 REDIM Flist(1:N)
130 OUTPUT @A;":CAL:FIELD:FREQUENCY? CHAN1"
140 !
150 ! Queries sensor for the frequencies
160 !
170 ENTER @A;Flist(*)
180 PRINT "Calibration Frequency List:"
190 !
200 ! Calibration frequencies are reported.
210 !
220 IMAGE 2X,DD.DD," GHz"
230 FOR I=1 TO N
240 PRINT USING 220;Flist(I)/1.E+9
250 NEXT I
260 END
```



**Measure Reflection Coefficient**



**Figure 6-2.**  
**Measure Reflection Coefficient- Equipment Setup**

This is the second step of the calibration procedure. The method for measuring both reflection magnitude ( $\Gamma$ : pronounced “gamma”) and reflection phase ( $\angle\Gamma$ ) of your peak power sensor using an HP 8510B/C network analyzer is described here.

**Test Equipment:**

Equipment	Recommended
Network Analyzer	HP 8510B/C
S parameter Test Set	HP 8515A/8517A
2.4 mm Calibration Kit	HP 85056D (HP 84814A)
3.5 mm Calibration Kit	HP 85052D (HP 84813A)
Type N Calibration Kit	HP 85054D (HP 84812A/84815A)
RF Source	Compatible with HP 8510B/C

**Description**

A one port calibration is performed on the network analyzer. This allows for a fully error-corrected reflection measurement on the sensor. A 50 ohm load, a short, and a shielded open are the standards necessary for this calibration.

Once the network analyzer is calibrated, the reflection coefficient is measured at the frequency of interest.

**Note**

There are several different methods to use your network analyzer to perform SWR measurements. The procedure that follows has been simplified. Using sliding loads and frequency lists could improve the accuracy of the results. Refer to your *HP 8510B/C Operating Manual*.

**Procedure**

1. Connect the peak sensor to the HP 899X.
2. Setup the network analyzer as described in your network analyzer manual.
  - a. Attach the appropriate 2.4mm, APC 3.5mm or Type N adapters to the network analyzer Port 1 Output.
  - b. Preset the network analyzer: press **PRESET**.
  - c. Under STIMULUS:
    - i. Press **MENU**.
    - ii. Press **STEP** softkey.
    - iii. From the display select a frequency resolution of at least 201 points.
    - iv. Press **Start**.
    - v. On the keypad, enter the lowest calibration frequency.
    - vi. Press **Stop**.
    - vii. Enter the highest calibration frequency.

- d. Under MENUS, press **CAL**
3. Calibrate the network analyzer according to your network analyzer manual. For example:
    - a. Select the 2.4 mm, 3.5 mm or Type N calibration from the softkey menu. For example: Press **3.5 mm - B 1**.

**Note**


---

If the calibration is not displayed follow the network analyzer operating manual to load your calibration.

---

- b. Press **S11 1 PORT** display key. The display should assign OPEN, SHORT, LOAD to display keys.
- c. Connect the OPEN from your calibration kit.
- d. Press **OPEN**. The display key will underline when complete.

**Note**


---

For type N connectors, you need to know the sex of the test port. For the 84812/15A the test port is female; press **OPEN (F)**. After the softkey gets underlined, press **DONE OPENS**.

---

- e. Connect the SHORT from your calibration kit.
- f. Press **SHORT**. The display key will underline.
- g. For type N press **SHORT (F)**; after it is underlined, press **DONE SHORTS**.
- h. Connect the LOAD.
- i. Press **LOAD**.
- j. Press **BROADBAND**. The display key will underline.
- k. Press **Done LOADS**.

1. Press **SAVE 1 PORT CAL**.

**Note**

---

You may have to delete a file to save your file.

---

- m. Select one of the files displayed to save the calibration.
4. Measure the reflection coefficient of the peak sensor.
    - a. Connect the peak power sensor to Port 1.
    - b. Under RESPONSE, press **MENU**
    - c. Press **AVERAGING ON/restart**. The softkey will underline.
    - d. Enter **1**, **6**, **X1** on the numbered keypad.
    - e. Under FORMAT, press **MENU**.
    - f. Press **LINEAR MAGNITUDE**. The softkey will underline.
    - g. Under MENUS, press **MARKER**.

**Note**

---

In the next step you should make a photocopy of Table 6-2, Table 6-3, Table 6-4, and Table 6-5 before entering data.

---

- h. Enter each calibration frequency on the network analyzer numbered keypad and record the reading in the  $\Gamma_{\text{dut}}$  column in Table 6-2. The reading is found in the upper left corner of the network analyzer display. Although the reading is in milli-Units, for calculation purposes, record the reading in Units (move the decimal 3 places to the left).
- i. At this time select and enter one non-calibration frequency, as well. Choose a frequency at which your signal generator is capable of outputting +9

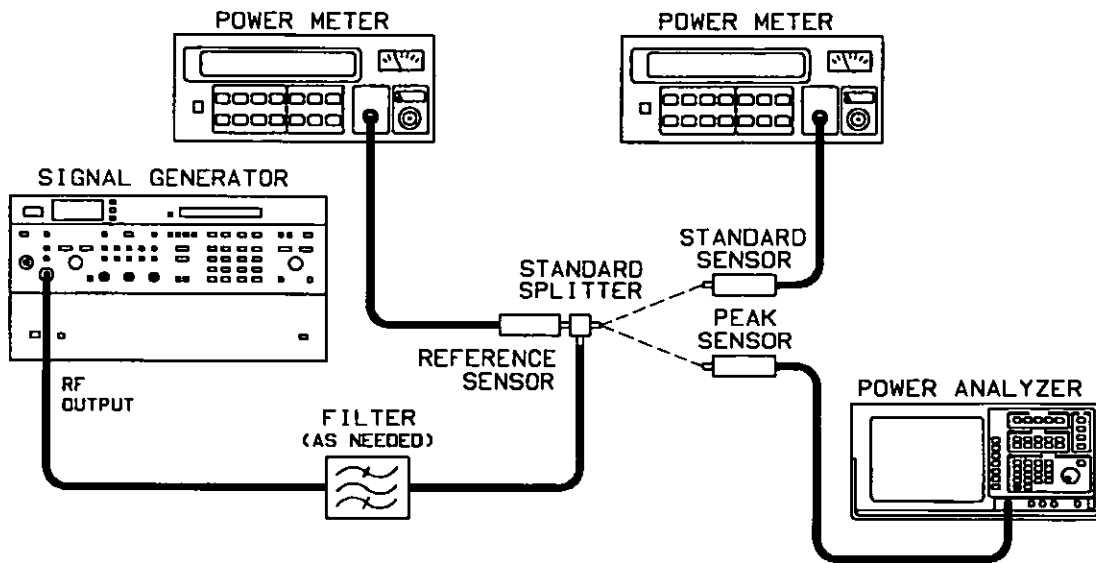
to +16 dBm. A non-calibration frequency is any frequency within the range of the sensor that is not used to calibrate the sensor. This non-calibration frequency magnitude and phase measurement will be used in the Power Variation Test to make sure the sensor measures power correctly at non-calibrated frequencies. Record this frequency and magnitude measurement in the  $\Gamma_{\text{dut}}$  column of Table 6-3.

- j. Under FORMAT, press **PHASE**.
- k. Enter each calibration frequency and record the phase reading in the  $\angle\Gamma_{\text{dut}}$  column of Table 6-2. The reading is found in the upper left corner of the network analyzer display.
- l. Take a phase measurement at your non-calibration frequency and record the reading in the  $\angle\Gamma_{\text{dut}}$  column of Table 6-3.

Refer to Table 2-1 Peak Power Sensor Specifications. The reflection coefficient magnitude measurement ( $\Gamma_{\text{dut}}$  in Table 6-2) must be less than the maximum reflection coefficient specification *at every calibration frequency*.

If the reflection coefficient is greater than the specifications in Table 2-1, the sensor fails calibration and should be repaired. Refer to the first part of chapter 5, Service, in this manual for peak sensor repair alternatives.

## Measure Power Levels



**Figure 6-3. Power Level Measurement Setup**

**Description** This is the third step of the calibration procedure. A known CW power level at each calibration frequency is measured through a standards laboratory calibrated power splitter by a “reference” average power sensor and compared to a standards laboratory calibrated average power sensor. The standards laboratory calibrated sensor is replaced by the peak power sensor “device under test (DUT)”. The signal power level is measured again by both the reference power sensor and the peak sensor.

**Equipment**

- Signal generator: HP 83732A (HP 84812A/15A only)
- Signal generator: HP 83640A (HP 84813A or 84814A)
- Peak power analyzer: HP 899X
- Average power meters (2): HP 437B
- Standards Lab Calibrated splitter: HP 11760S K03 (HP 84812A/15A only)
- Standards Lab Calibrated splitter: HP 11760S K05 (HP 84813A only)
- Standards Lab Calibrated splitter: HP 11760S K13 (HP 84814A only)
- Standards Lab Calibrated sensor: HP 8481A H84 (HP 84812A/15A only)
- Standards Lab Calibrated sensor: HP 8485A H84 (HP 84813A only)
- Standards Lab Calibrated sensor: HP 8487A H84 (HP 84814A only)
- Average sensor: HP 8481A (HP 84812A/15A only)
- Average sensor: HP 8485A (HP 84813A only)
- Average sensor: HP 8487A (HP 84814A only)

**Note**

---

Filters may be required to get harmonics and spurious signals of the signal generator below the  $-50$  dBc limit of the carrier frequency signal.

---

**Preparation**

1. Enter the calibration factor table from your average power sensor labels or from your calibration report into each HP 437B power meter according to the *HP 437B Operating Manual*. This will allow the average power meters to automatically interpolate for unlisted cal factor frequencies. To find out how to enter sensor cal factor tables look under "Sensor" and "Sensor Data" in chapter 3, Detailed Operating Instructions in the *HP 437B Operating Manual*.
2. Zero and calibrate your average power sensors according to the instructions in your power meter operating manual.

3. *Reminder.* The HP 899X should be warmed up and calibrated. Preset and zero the analyzer and peak power sensor by pressing the following keys: (The peak sensor must not be connected to any signal.)
  - a. Press **LOCAL**.
  - b. Preset the analyzer: press **RECALL**, then **CLEAR**.
  - c. Under **MENUS**, press **DISPLAY**.
  - d. On the display keys press **DISPLAY** until the **avg** is highlighted.
  - e. Use the knob to enter 16.
  - f. Under **MENUS**, press **CHAN/VERT**.
  - g. Press **sensor zero**.
  - h. Wait a moment. The analyzer display should respond with:

sensor zero completed

### Procedure

1. Set up your system as shown in Figure 6-3. Connect the standard sensor (standards lab calibrated average power sensor) to the calibrated port of the splitter. The calibrated port is identified on the calibration report from the calibration lab.
2. Set the signal generator to the calibration frequency of interest. See Table 6-2.
3. Enter the calibration frequency into both average power meters.
4. Adjust the signal generator output power level until the reference average power meter reads 1 mW  $\pm 0.1$  mW for frequencies  $\leq 18$  GHz, and  $250\mu\text{W}$   $\pm 25\mu\text{W}$  for frequencies  $> 18$  GHz..
5. Record in Table 6-2 data table the average power,  $P_{\text{std}}$  and  $P_{\text{ref}}$ , as measured by the standard sensor and the reference sensor, respectively.
6. Repeat steps 2 through 5 for each calibration frequency.



7. Replace the standard power sensor and meter with the peak power sensor to be calibrated and HP 899X peak power analyzer. Refer to Figure 6-3.
8. Take a CW power measurement with the peak power analyzer, press:
  - a. Press **AUTOSCALE**.
  - b. Press **Blue** shift key.
  - c. Press **avg** on the keypad.
  - d. Press **1** on the keypad.
9. On the peak power analyzer, under MENUS, press **CARRIER FREQ**.
10. Set the signal generator to the calibration frequency of interest. See Table 6-2.
11. Enter the calibration frequency on the analyzer keypad.
12. On the reference (average) power meter enter the calibration frequency.
13. Adjust the signal generator output power level until the reference average power meter reads approximately  $1 \text{ mW} \pm 0.1 \text{ mW}$  for frequencies  $\leq 18 \text{ GHz}$ , and  $250 \mu\text{W} \pm 25 \mu\text{W}$  for frequencies  $> 18 \text{ GHz}$ .
14. Record in Table 6-2 the reference power meter reading ( $P_{\text{ref}}$ ) and the peak analyzer reading ( $P_{\text{dut}}$ ). The reading appears in the lower left area of the peak analyzer display.
15. Repeat steps 10 through 14 for each calibration frequency.
16. Leave the test setup intact while you perform the Calculate Transfer Cal Factors and Download Transfer Cal Factors procedures.

## Calculate Transfer Cal Factor Percentage

This is the fourth step in the calibration procedure. This procedure uses the measurements you have just made in the second step (where you measured reflection coefficient) and third step (where you measured power levels) to calculate the transfer calibration factor percentages (Cf) you will download to the sensor EEPROM in step 5.

### Note

Due to the complexity of the calculations, we suggest using the Calculating Cf Program (HP Basic 3.0 or greater have the necessary math functions) the end of this procedure. The Calculating CF Example can be used as a guide to help you to use one of the popular spreadsheet programs available for personal computers.

### Calculate Cf

1. Calculate the incident power level to the standard sensor.

$$P_{ist} = P_{std} | (1 - \Gamma_{std} \Gamma_{sp})^2 |$$

where:

$\Gamma_{std} \Gamma_{sp}$  is a complex number (see Calculating Cf Example).

$P_{ist} \equiv$  incident power to the standard sensor

$P_{std} \equiv$  power measured by the standard sensor

$\Gamma_{std} \equiv$  reflection coefficient of standard sensor

$\Gamma_{sp} \equiv$  equivalent source match of splitter

$\Gamma$ , gamma,  $\equiv |\Gamma|, \angle \Gamma$

2. Calculate the incident power level on the DUT sensor.

$$P_{idut} = \frac{(P'_{ref})(P_{ist})}{P_{ref}}$$

where:

$P_{idut} \equiv$  incident power to the DUT sensor

$P'_{ref} \equiv$  power measured by reference sensor with DUT sensor

$P_{ref} \equiv$  power measured by reference sensor with standard sensor.

3. Calculate theoretical power to the DUT sensor.

$$P_d = \frac{P_{idut}}{|(1 - \Gamma_{sp}\Gamma_{dut})^2|}$$

where:

$P_d \equiv$  theoretical power to the DUT sensor.

$\Gamma_{dut} \equiv$  complex reflection coefficient of DUT

4. Calculate the cal factor percentage (Cf)

$$Cf = \left( \frac{P_{dut}}{P_d} \right) (100)$$

where:

Cf  $\equiv$  transfer calibration factor

$P_{dut} \equiv$  power measured by the DUT

### Calculating Cf Example

This is an example of a transfer cal factor calculation for a hypothetical calibration frequency of 16 GHz.

- The values  $\Gamma_{sp}$  and  $\angle\Gamma_{sp}$  are from the standards laboratory calibration report for the splitter.
- The values  $\Gamma_{std}$  and  $\angle\Gamma_{std}$  are from the standards laboratory calibration report for the standard sensor.
- The values  $\Gamma_{dut}$  and  $\angle\Gamma_{dut}$  are from step 2 of this calibration procedure.
- The values  $P_{std}$ ,  $P_{ref}$ ,  $P_{dut}$ , and  $P'_{ref}$ , are from step 3 of this calibration procedure.

Given the following data:

**From Table 6-2 Calibration Factor at Calibration Frequency Data**

Freq. (GHz)	$\Gamma_{sp}$	$\angle\Gamma_{sp}$	$\Gamma_{std}$	$\angle\Gamma_{std}$	$\Gamma_{dut}$	$\angle\Gamma_{dut}$	$P_{std}$ (mW)	$P_{ref}$ (mW)	$P_{dut}$ (mW)	$P'_{ref}$ (mW)	Cf (%)
16	.0638	-136.9	.053	104.7	.0392	94.484	1.008	1	.968	1	

1. Using the following formula:

$$P_{ist} = P_{std}|(1 - \Gamma_{std}\Gamma_{sp})^2|$$

We convert the complex number

$$\Gamma_{std}\Gamma_{sp}$$

by modifying the formula to:

$$P_{ist} = P_{std}[(1 - |\Gamma_{std}\Gamma_{sp}|\cos(\angle\Gamma_{std} + \angle\Gamma_{sp}))^2 + (|\Gamma_{std}\Gamma_{sp}|\sin(\angle\Gamma_{std} + \angle\Gamma_{sp}))^2]$$

Substituting data into this formula we get:

$$P_{ist} = 1.008[(1 - (.053)(.0638)\cos(104.7 - 136.9))^2 + ((.053)(.0638)\sin(104.7 - 136.9))^2]$$

This gives us incident power to the standard sensor as:

$$P_{ist} = 1.003184866$$

2. Using the formula:

$$P_{idut} = \frac{(P'_{ref})(P_{ist})}{P_{ref}}$$

Substituting data into this formula we get:

$$P_{idut} = \frac{(1)(1.003184866)}{(1)}$$

This gives us power incident to the peak sensor as:

$$P_{idut} = 1.003184866$$

3. And using the following formula:

$$P_d = \frac{P_{idut}}{|(1 - \Gamma_{sp}\Gamma_{dut})^2|}$$

We convert the complex numbers to get:

$$P_d = \frac{P_{idut}}{(1 - |\Gamma_{sp}\Gamma_{dut}|\cos(\angle\Gamma_{sp} + \angle\Gamma_{dut}))^2 + (|\Gamma_{sp}\Gamma_{dut}|\sin(\angle\Gamma_{sp} + \angle\Gamma_{dut}))^2}$$

Now substituting the data:

$$P_d = \frac{1.003184866}{(1 - (.0638)(.0392)\cos(-136.9 + 94.484))^2 + ((.0638)(.0392)\sin(-136.9 + 94.484))^2}$$

This gives us a theoretical power to the peak sensor as:

$$P_d = 1.003201168$$

4. Finally, using the formula:

$$Cf = \left( \frac{P_{dut}}{P_d} \right) (100)$$

Substituting the data:

$$Cf = \left( \frac{.968}{1.003201168} \right) (100)$$

This gives us a transfer cal factor percentage of:

96.5%

## Calculating CF Program

Copy and save the following program to generate your transfer calibration factor percentages. The program will prompt you to enter the data for each frequency. Copy the resultant transfer cal factor percentages into the Cf (%) column of Table 6-2.

```

10 PRINT "The following program will calculate the cal factor."
20 INPUT "Enter the freq in GHz.",Freq
30 INPUT "Enter GAMMAsp:",Gamsp
40 INPUT "Enter the angle GAMsp:",Agamsp
50 INPUT "Enter GAMstd:",Gamstd
60 INPUT "Enter the angle GAMstd:",Agamstd
70 INPUT "Enter GAMdut:",Gamdut
80 INPUT "Enter the angle GAMdut:",Agamdut
90 INPUT "Enter Pstd:",Pstd
100 INPUT "Enter Pref:",Pref
110 INPUT "Enter Pdut:",Pdut
120 INPUT "Enter P'ref:",Pref2
130 PRINT "Please wait while I calculate the cal factor."
140 A=Gamstd*Gamsp
150 B=Agamstd+Agamsp
160 Pist=Pstd*((1-A*COS(B))^2+(A*SIN(B))^2)
170 Pidut=Pref2*Pist/Pref
180 C=Gamdut*Gamsp
190 D=Agamdut+Agamsp
200 Pd=Pidut/(1-C*COS(D))^2+(C*SIN(D))^2
210 Cf=Pdut/Pd*100
220 Cfpercent=PROUND(Cf,-1)
230 PRINT "The Cal Factor ";Freq;" GHz is: ";Cfpercent;" %."
240 INPUT "Enter 'Y' or 'y' if more calculation are required.",A$
250 If A$="Y" OR A$="y" THEN GOTO 20
260 PRINT "The calculations are complete."
270 END

```

## Download Transfer Cal Factors

This procedure uses a program to download transfer calibration factor percentage (Cf) to the sensor EEPROM.

### Note

The sensor EEPROM will round up the calibration factor percentage to the nearest 0.4%. For example: You enter 96.5 as a cal factor percentage for 16 GHz. Later, if you query the sensor EEPROM using ":CAL:FIELD:DATA?", the EEPROM will report a cal factor percentage of 96.8.

- Leave the equipment set up as shown in Figure 6-3, but connect the controller to the HP 899X peak power analyzer via HP-IB as shown in Figure 6-1.
- Download Cf to the peak power sensor EEPROM using the following program.

### Caution

DO NOT disconnect the sensor or cycle power while executing any read or write function to the peak power sensor EEPROM. If this happens, the peak power sensor EEPROM will be erased. This condition is not user repairable. The peak power sensor must be sent back to Hewlett-Packard for calibration.

```

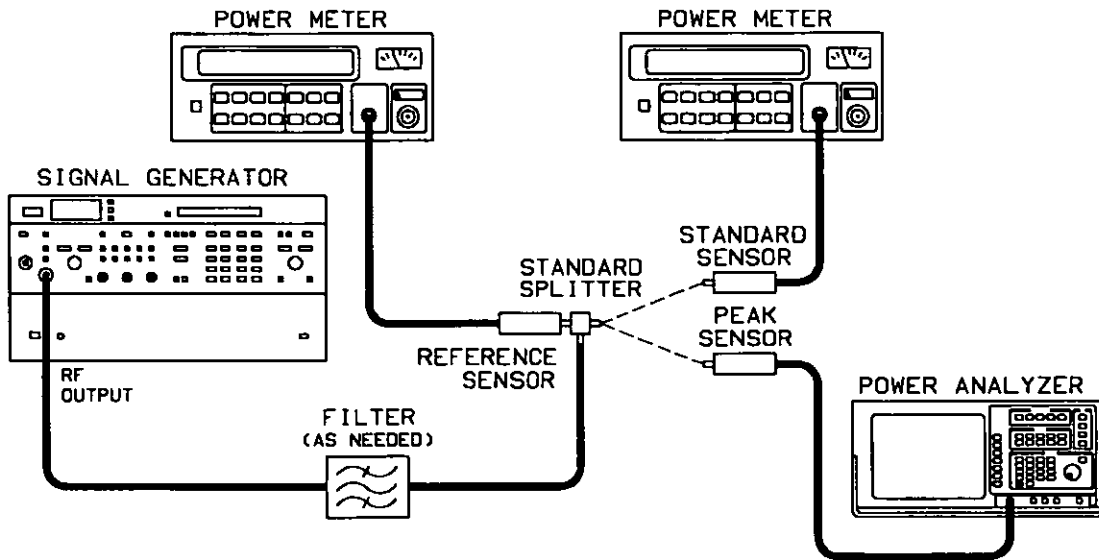
10  !   Transfer cal factor downloading program
20  DIM Flist(50), Clist(50)
30  ASSIGN @A to 707
40  !
50  ! Read number of field cal points.
60  !
70  OUTPUT @A;":CAL:FIELD:POINTS? CHAN1"
80  ENTER @A;N
90  PRINT "CHAN1 #of field cal points: ";N
100 !
110 ! Read field cal test frequencies.
120 !

```



```
130 REDIM Flist(1:N)                ! Make space for N
freqs.
140 OUTPUT @A;":CAL:FIELD:FREQUENCY? CHAN1"
150 ENTER @A;Flist(*)              ! Get freq array.
160 !
170 ! Get correction factors from user.
180 !
190 REDIM Clist(1:N)               ! Make space for N
values.
200 PRINT
210 PRINT "Correction Factors:"
220 FOR I=1 to N
230   IMAGE #,2X,DD.DD," GHz"
240   PRINT USING 230;Flist(I)/1.E+9
250   Clist(I)=100.0                ! Default.
260   INPUT "Enter the correction factor for this
frequency:",Clist(I)
270   IMAGE 4X,DDD.DD
280   PRINT USING 270;Clist(I)
290 NEXT I
300 !
310 ! Send new cal factors out.
320 !
330 IMAGE #,":CAL:FIELD:DATA CHAN1,"
340 OUTPUT @A USING 330
350 IMAGE #,DDD.DD,",,"           ! No linefeed, trailing
comma.
360 FOR I=1 to N-1                ! For each value except
last....
370   OUTPUT @A USING 350;Clist(I) ! Each value get trailing
comma.
380 NEXT I
390 OUTPUT @A;Clist(N)            ! Send final value, no comma.
400 !
410 PRINT "CF data has been entered."
420 END
```

## Power Variation Testing



**Figure 6-4. Power Level Variation Test**

This is the sixth step of the calibration procedure.

In the procedures that follow, you will compare the results of your newly calibrated peak power sensor to your calibrated average sensor and record your test results in a copy of Table 6-4 and Table 6-5.

### Note

It is assumed your test equipment settings and setup are the same as what you used in Measure the Power Levels procedure, earlier.

**Procedure**

1. Set up your system as shown in Figure 6-4. Connect the standard sensor (standards lab calibrated average power sensor) to the calibrated port of the splitter.
2. Set the signal generator frequency to the frequency you entered in Table 6-3.
3. In Table 6-4 and Table 6-5, enter the same non-calibration frequency you entered in Table 6-3.
4. Enter the frequency into both average power meters.
5. Adjust the signal generator output power level until the reference average power meter reads approximately  $100 \mu\text{W} \pm 5 \mu\text{W}$ .
6. Record in Table 6-4 the average power,  $P_{\text{std}}$  and  $P_{\text{ref}}$ , as measured by the standard sensor and the reference sensor, respectively.

**200  $\mu\text{W} \pm 10 \mu\text{W}$  Test with standard sensor**

7. Adjust the signal generator power level until the reference power meter reads  $200 \mu\text{W} \pm 10 \mu\text{W}$ .
8. Record in Table 6-5 the average power,  $P_{\text{std}}$  and  $P_{\text{ref}}$ , as measured by the standard sensor and the reference sensor, respectively.

**With peak sensor**

9. Replace the standard power sensor and meter with the peak sensor (DUT) and HP 899X peak power analyzer. Refer to Figure 6-4.
10. On the analyzer, press **LOCAL**.
11. Press **CARRIER FREQ**.
12. Enter the non calibration frequency on the peak analyzer keypad.

13. Adjust the signal generator power level output until the reference average power meter reads approximately  $100 \mu\text{W} \pm 5 \mu\text{W}$ .
14. Press **AUTOSCALE** on peak power analyzer.
15. Take a CW power measurement with the peak power analyzer, press:
  - a. Press **Blue** shift key.
  - b. Press **avg** on the keypad.
  - c. Press **1** on the keypad.
16. Record in Table 6-4 the reference power meter reading ( $P'_{ref}$ ) and the analyzer reading ( $P_{dut}$ ).

#### 200 $\mu\text{W}$ Test with peak sensor

17. Adjust the signal generator power level you set in step 7.
18. Press **AUTOSCALE**.
19. Record in Table 6-4 the reference power meter reading ( $P'_{ref}$ ) and the peak analyzer CW power reading ( $P_{dut}$ ).

#### Calculate %Error

20. Calculate the %Error using some of the same formulas you used in the Calculating Cf Example, earlier.

$$P_{ist} = P_{std} |(1 - \Gamma_{std} \Gamma_{sp})^2|$$

$$P_{idut} = \frac{(P'_{ref})(P_{ist})}{P_{ref}}$$

$$P_d = \frac{P_{idut}}{|(1 - \Gamma_{sp} \Gamma_{dut})^2|}$$

$$\%Error = \left( \frac{P_d - P_{dut}}{P_d} \right) (100)$$

21. Record in Table 6-4 and Table 6-5.

Compare this %Error to the Sensor Calibration RSS uncertainty listed in Table 2-1. Remember the specification is range specific. For example, if you chose 9 GHz as your non-calibration frequency, compare the %Error to the specification for the < 12 GHz range. If the %Error is greater than the uncertainty specifications, the peak sensor fails calibration and must be repaired.

**Note**

---

If the %Error fails by less than two percent, repeating the complete calibration might improve the %Error. For example, if 9 GHz is your non-calibration frequency and your %Error is 5.8% or less, the error could be attributed to faulty connections. As noted earlier, follow the procedures in Application Note 326 when making or breaking connections.

---



Table 6-4. 100  $\mu$ W Power Level Data

Freq. (GHz)	$P_{std}$ ( $\mu$ W)	$P_{ref}$ ( $\mu$ W)	$P_{dut}$ ( $\mu$ W)	$P'_{ref}$ ( $\mu$ W)	% Error

Table 6-5. 2 mW to 20 mW Power Level Data

Freq. (GHz)	$P_{std}$ (mW)	$P_{ref}$ (mW)	$P_{dut}$ (mW)	$P'_{ref}$ (mW)	% Error

Table 6-6. Hewlett-Packard Sales and Service Offices

US FIELD OPERATIONS		
<b>Headquarters</b> Hewlett-Packard Company 19320 Pruneridge Avenue Cupertino, CA 95014, USA (800) 752-0900	<b>California, Northern</b> Hewlett-Packard Co. 301 E. Evelyn Mountain View, CA 94041 (415) 694-2000	<b>California, Southern</b> Hewlett-Packard Co. 1421 South Manhattan Ave. Fullerton, CA 92631 (714) 999-6700
<b>Colorado</b> Hewlett-Packard Co. 24 Inverness Place, East Englewood, CO 80112 (303) 649-5000	<b>Georgia</b> Hewlett-Packard Co. 2000 South Park Place Atlanta, GA 30339 (404) 955-1500	<b>Illinois</b> Hewlett-Packard Co. 5201 Tollview Drive Rolling Meadows, IL 60008 (708) 255-9800
<b>New Jersey</b> Hewlett-Packard Co. 150 Green Pond Road Rockaway, NJ 07866 (201)627-6400	<b>Texas</b> Hewlett-Packard Co. 930 E. Campbell Rd. Richardson, TX 75081 (214) 231-6101	
EUROPEAN FIELD OPERATIONS		
<b>Headquarters</b> Hewlett-Packard S.A. 150, Route du Nant-d'Avril 1217 Meyrin 2/Geneva Switzerland (41 22) 780.8111	<b>France</b> Hewlett-Packard France 1 Avenue Du Canada Zone D'Activite De Courtaboeuf F-91947 Les Ulis Cedex France (33 1) 69 82 60 60	<b>Germany</b> Hewlett-Packard GmbH Hewlett-Packard Strasse 6380 Bad Homburg v.d.H Germany (49 6172) 16-0
<b>Great Britain</b> Hewlett-Packard Ltd Eskdale Road, Winnersh Triangle Wokingham, Berkshire RF11 5DZ England (44 734) 696622		
INTERCON FIELD OPERATIONS		
<b>Headquarters</b> Hewlett-Packard Company 3495 Deer Creek Rd. Palo Alto, California 94304-1316 (415) 857-5027	<b>Australia</b> Hewlett-Packard Australia Ltd. 31-41 Joseph Street Blackburn, Victoria 3130 (61 3) 895-2895	<b>Canada</b> Hewlett-Packard (Canada) Ltd. 17500 South Service Road Trans-Canada Highway Kirkland, Quebec H9J 2X8 Canada (514) 697-4232
<b>China</b> China Hewlett-Packard Co. 38 Bei San Huan X1 Road Shuang Yu Shu Hai Dian District Beijing, China (86 1) 256-6888	<b>Japan</b> Yokogawa-Hewlett-Packard Ltd. 1-27-15 Yabe, Sagami-hara Kanagawa 229, Japan (81 427) 59-1311	<b>Singapore</b> Hewlett-Packard Singapore (Pte.) Ltd 1150 Depot Road Singapore 0410 (65) 273-7388
<b>Taiwan</b> Hewlett-Packard Taiwan 8th Floor, H-P Building 337 Fu Hsing North Road Taipei, Taiwan (886 2) 712-0404		



Service needed

- CALIBRATION ONLY
- REPAIR       REPAIR & CAL

OTHER \_\_\_\_\_

Observed symptoms/problems

FAILURE MODE IS:

- CONSTANT       INTERMITTENT

SENSITIVE TO:

- COLD       HEAT       VIBRATION

FAILURE SYMPTOMS/  
SPECIAL CONTROL SETTINGS \_\_\_\_\_

---

---

---

---

---

---

---

---

---

---

If unit is part of system list model number(s) of  
other interconnected instruments. \_\_\_\_\_

Service needed

- CALIBRATION ONLY
- REPAIR       REPAIR & CAL

OTHER \_\_\_\_\_

Observed symptoms/problems

FAILURE MODE IS:

- CONSTANT       INTERMITTENT

SENSITIVE TO:

- COLD       HEAT       VIBRATION

FAILURE SYMPTOMS/  
SPECIAL CONTROL SETTINGS \_\_\_\_\_

---

---

---

---

---

---

---

---

---

---

If unit is part of system list model number(s) of  
other interconnected instruments. \_\_\_\_\_

Service needed

- CALIBRATION ONLY
- REPAIR       REPAIR & CAL

OTHER \_\_\_\_\_

Observed symptoms/problems

FAILURE MODE IS:

- CONSTANT       INTERMITTENT

SENSITIVE TO:

- COLD       HEAT       VIBRATION

FAILURE SYMPTOMS/  
SPECIAL CONTROL SETTINGS \_\_\_\_\_

---

---

---

---

---

---

---

---

---

---

If unit is part of system list model number(s) of  
other interconnected instruments. \_\_\_\_\_



Should one of your HP instruments need repair, the HP service organization is ready to serve you. However, you can help us serve you more effectively. When sending an instrument to HP for repair, please fill out this card and attach it to the product. Increased repair efficiency and reduced turn-around time should result.

COMPANY \_\_\_\_\_

ADDRESS \_\_\_\_\_

TECHNICAL CONTACT PERSON \_\_\_\_\_

PHONE NO. \_\_\_\_\_ EXT. \_\_\_\_\_

MODEL NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

MODEL NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

P.O. NO. \_\_\_\_\_ DATE \_\_\_\_\_

Accessories returned with unit

- NONE       CABLE(S)  
 POWER CABLE       ADAPTER(S)

OTHER \_\_\_\_\_

over



Should one of your HP instruments need repair, the HP service organization is ready to serve you. However, you can help us serve you more effectively. When sending an instrument to HP for repair, please fill out this card and attach it to the product. Increased repair efficiency and reduced turn-around time should result.

COMPANY \_\_\_\_\_

ADDRESS \_\_\_\_\_

TECHNICAL CONTACT PERSON \_\_\_\_\_

PHONE NO. \_\_\_\_\_ EXT. \_\_\_\_\_

MODEL NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

MODEL NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

P.O. NO. \_\_\_\_\_ DATE \_\_\_\_\_

Accessories returned with unit

- NONE       CABLE(S)  
 POWER CABLE       ADAPTER(S)

OTHER \_\_\_\_\_

over



Should one of your HP instruments need repair, the HP service organization is ready to serve you. However, you can help us serve you more effectively. When sending an instrument to HP for repair, please fill out this card and attach it to the product. Increased repair efficiency and reduced turn-around time should result.

COMPANY \_\_\_\_\_

ADDRESS \_\_\_\_\_

TECHNICAL CONTACT PERSON \_\_\_\_\_

PHONE NO. \_\_\_\_\_ EXT. \_\_\_\_\_

MODEL NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

MODEL NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

P.O. NO. \_\_\_\_\_ DATE \_\_\_\_\_

Accessories returned with unit

- NONE       CABLE(S)  
 POWER CABLE       ADAPTER(S)

OTHER \_\_\_\_\_

over

\*\* For HP Internal Reference Only \*\*

Customer Order Number

Manufacturing Part Number

**5960-7081**



Printed in USA December 1993