Errata

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. To reduce potential confusion, the only change to product numbers and names has been in the company name prefix: where a product number/name was HP XXXX the current name/number is now Agilent XXXX. For example, model number HP8648 is now model number Agilent 8648.

Ce manuel peut contenir des références à <<HP>> ou <<Hewlett-Packard.>> Veuillez noter que les produits de test et mesure, de semi-conducteur et d'analyse chimique qui avaient fait partie de la société Hewlett-Packard sont maintenent une partie de la société Agilent Technologies. Pour reduire la confusion potentielle, le seul changement aux noms de reference a été dans le préfixe de nom de société : là où un nom de référence était HP XXXX, le nouveau nom de référence est maintenant Agilent XXXX. Par example, le HP 8648 s'appelle maintenent Agilent 8648.

Diese Gebrauchsanweiseung kann Bezug nehmen auf die Namen HP oder Hewlett-Packard. Bitte beachten Sie, dass ehemalige Betriebsbereiche von Hewlett-Packard wie HP-Halbleiterprodukte, HP-chemische Analysen oder HP-Test- und Messwesen nun zu der Firma Agilent Technology gehören. Um Verwirrung zu vermeiden wurde lediglich bei Produktname und - Nummer der vo laufende Firmenname geändert: Produkte mit dem Namen/Nummer HP XXXX lauten nun mehr Agilent XXXX. Z.B, das Modell HP 8648 heißt nun Agilent 8648.

Questo manuale potrebbe contenere riferimenti ad HP o Hewlett-Packard. Si noti che le attività precedentemente gestite da Hewlett-Packard nel campo di Test & Misura, Semiconduttori, ed Analisi Chimica sono ora diventate parte di Agilent Technologies. Al fine di ridurre il rischio di confusione, l'unica modifica effettuata sui numeri di prodotto e sui nomi ha riguardato il prefisso con il nome dell'azienda : dove precedentemente compariva "HP XXXX" compare ora "Agilent XXXX". Ad esempio: il modello HP8648 è ora indicato come Agilent 8648.

Este manual puede hacer referencias a HP o Hewlett Packard. Las organizaciones de Prueba y Medición (Test and Measurement), Semiconductores (Semiconductor Products) y Análisis Químico (Chemical Analysis) que pertenecían a Hewlett Packard, ahora forman parte de Agilent Technologies. Para reducir una potencial confusión, el único cambio en el número de producto y nombre, es el prefijo de la compañía: Si el producto solía ser HP XXXX, ahora pasa a ser Agilent XXXX. Por ejemplo, el modelo HP8648 es ahora Agilent 8648.

这个手册里面可能含有惠普公司的资料. 请注意惠普公司以前的测试, 半导体产品, 化学分析部门现在属于安捷伦公司. 为了减少可能的误解, 产品号码和名字只改变最前面的公司名字. 如果一个产品的号码/名字以前是HP XXXX, 现在的号码/名字是安捷伦 XXXX. 例如模型号码是惠普8648. 现在是模型号码安捷伦8648.

Agilent Technologies

マニュアル・チェンジ

変更

本文中の「HP(YHP)」、または「(横河)ヒューレット・パッカード株式会社」という語句を、「Agilent」、または「アジレント・テクノロジー株式会社」と変更してください。

ヒューレット・パッカード社の電子計測、半導体製品、化学分析ビジネス部門は分離独立し、アジレント・テクノロジー社となりました。
社名変更に伴うお客様の混乱を避けるため、製品番号の接頭部のみ変更しております。
（例: 旧製品名　HP 4294A　は、現在　Agilent 4294A　として販売いたしております。）

Operating and Service Manual
HP 84812A/13A/14A
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: 3113A
HP 84813A: To be assigned.
HP 84814A: To be assigned.

HEWLETT PACKARD

About the Sensor

Sensor Description   The HP 84812A, 84813A, and 84814A Peak Power
Sensors are specifically designed to be used with the
HP 8990A Peak Power Analyzer. Together, any of the
three Sensors and the analyzer comprise the power
measurement system which senses and displays envelope
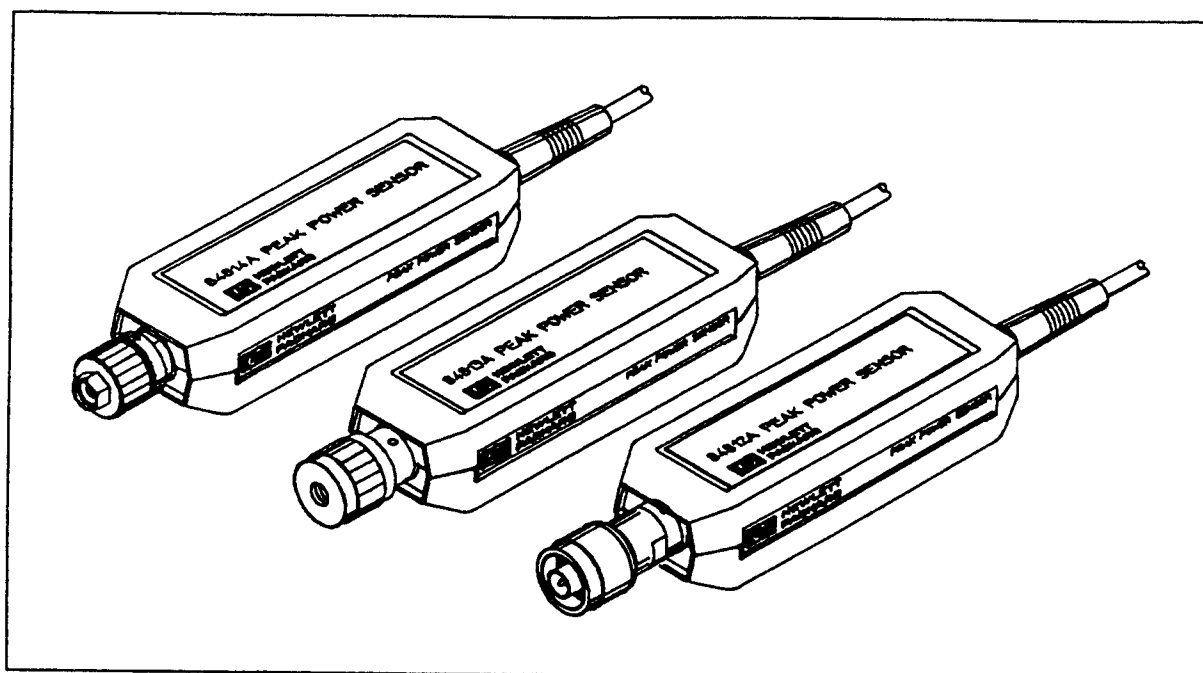power in the range of -32 to +20 dBm.

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 8990A
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
or 84814A Peak Power Sensors.

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

Note

The specified risetime for an HP 8990A using a Sensor
with the Option 001 (20 ft Sensor cable) is <10 ns.
Risetime is <5 ns using the standard (5 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: Frequency Range 84813A: Frequency Range 84814A:	500 MHz to 18 GHz 500 MHz to 26.5 GHz 500 MHz to 40 GHz
Dynamic Range:	-32 to +20 dBm (Usable to -40 dBm.)
Sensor Calibration RSS Uncertainty:	< 4 GHz: ±3.6% < 12 GHz: ±3.8% < 18 GHz: ±4.3% <26.5 GHz: ±5.5% < 40 GHz: ±6.5%
Input SWR, max (Reflection Coefficient):	500 MHz to 18 GHz: 1.25 (0.11) 18 to 26.5 GHz: 1.35 (0.15) 26.5 GHz to 40 GHz: 1.60 (0.23)
Maximum Power Input:	1 W peak power for 1 μs, not to exceed 200 mW (CW)
Operating Temperature: Acoustic Noise Emissions: Geraeuschemission:	0°C to +55°C No Fan Installed Kein Ventilator Eingebaut

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

General Characteristics	
Connector HP 84812A:	Type-N Male
Connector HP 84813A:	APC-3.5 mm Male
Connector HP 84814A:	2.4 mm Male
Sensor Cable Length:	1.5 M (5 ft)
Option 001:	6.1 M (20 ft)
Calibration Interval:	18 months
Parameters Corrected for:	Frequency, Temperature, and Power Non-linearity.
Dimensions HP 84812A:	27mm H, 37mm W, 137mm L (1.05" x 1.45" x 5.4")
Dimensions HP 84813A:	27mm H, 37mm W, 127mm L (1.05" x 1.45" x 5.0")
Dimensions HP 84814A:	27mm H, 37mm W, 127mm L (1.05" x 1.45" x 5.0")
Weight:	Net: 0.35 kg (0.8 lb); Shipping: 1 kg (2 lb)
Option 001:	Net: 0.8 kg (1.5 lb); Shipping: 1.5 kg (3 lb)

6

Calibration

Introduction

After 18 months of normal use, your HP 84812A, 84813A or 84814A 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 or Support 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 8990A
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	500 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	500 MHz to 26.5 GHz ≤ -50 dBc harmonics and spurious signals	HP 8673D
	500 MHz to 40 GHz ≤ -50 dBc harmonics and spurious signals	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,only)	HP 11760S K03
Average Power Meter	2 each. No substitute	HP 437B
Average Sensor	Power Range: 1μW 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,only) Freq. Range: 500 MHz to 18 GHz	HP 8481A

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

Instrument Type	Critical Specifications	Suggested Model
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): 2 — 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): 2 — 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 (only)	HP 85032B

Preparing for Calibration

Before beginning the procedure, the HP 8990A should be ON and warmed up for at least one hour. After the initial warmup 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.

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.

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.**

■ 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,
    Specification) 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 08510-90064).

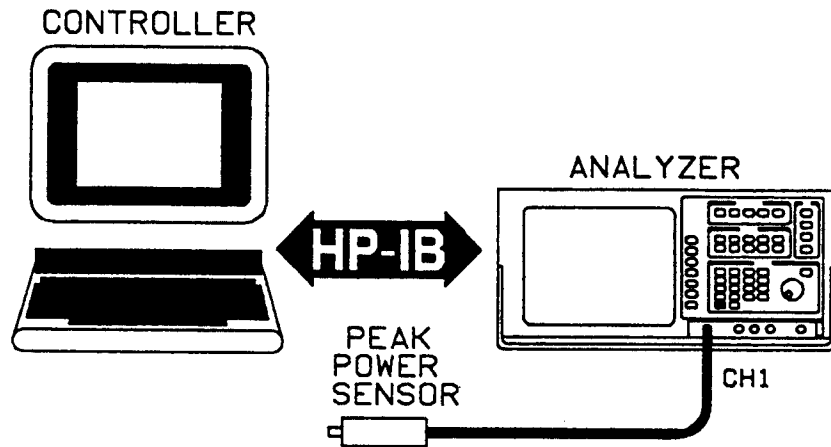# Read Peak Power Sensor Calibration Frequencies

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 8990A 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 `5` is highlighted

d. Toggle `field cal off/on` softkey until `off` is
highlighted.

2. Connect the controller via HP-IB to the HP 8990A
Analyzer.

3. Connect your Peak Power Sensor to Channel 1 of the
analyzer.

4. Type in and save 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.

```
10    DIM Flist(50),A$[300]
20    ASSIGN @A TO 707
30    !
40       ! 707 is HP 8990A 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
```
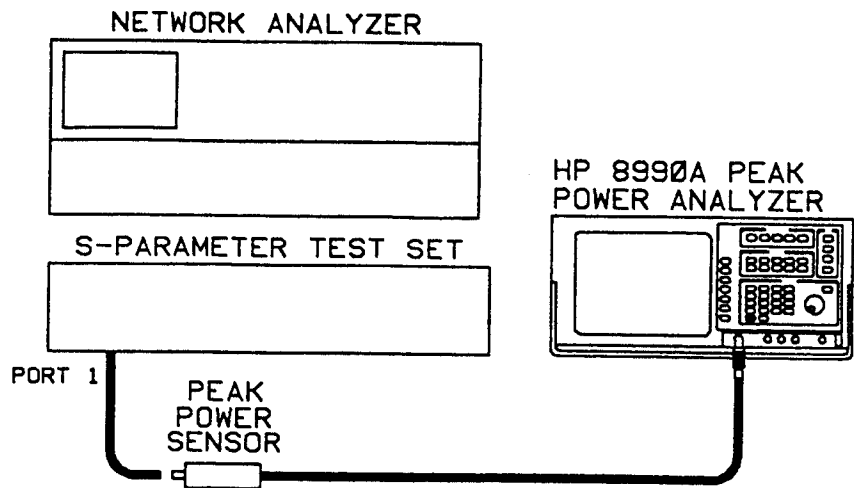
Measure Reflection Coefficient

Figure 6-2.
Measure Reflection Coefficient- Equipment Setup

This is the second step of the calibration procedure.
The method for measuring both reflection magnitude
(Γ: 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 85032B (HP 84812A)
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 8990A.

                     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 $\boxed{\text{CAL}}$

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.

e. Connect the SHORT from your calibration kit.

f. Press `SHORT`. The display key will underline.

g. Connect the LOAD.

h. Press `LOAD`.

i. Press `BROADBAND`. The display key will underline.

j. Press `Done LOADS`.

k. Press `SAVE 1 PORT CAL`.

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

---

l. 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 Γ_{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. 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 Γ_{dut} column of Table 6-3.

j. Under FORMAT, press (PHASE).

k. Enter each calibration frequency and record the
phase reading in the $\angle\Gamma_{dut}$ 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 $\angle\Gamma_{dut}$
column of Table 6-3.

Refer to Table 2-1 Specifications. The reflection
coefficient magnitude measurement (Γ_{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
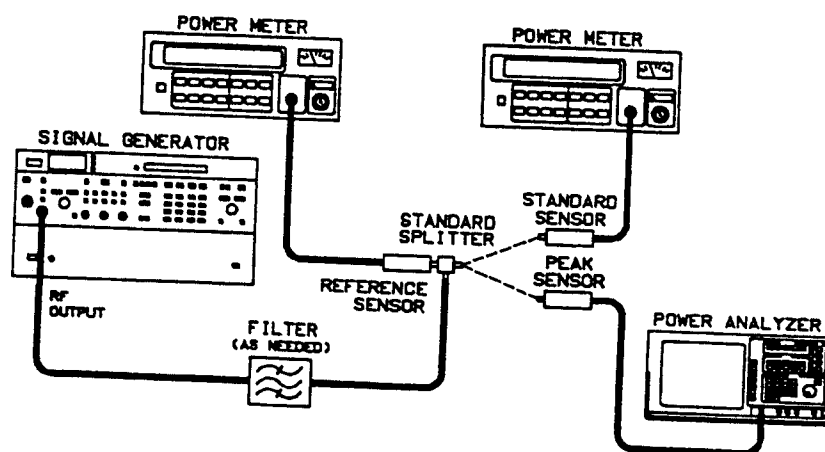alternatives.

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 8673C (HP 84812A,only)
■ Signal Generator: HP 8673D (HP 84812A or 84813A)
■ Signal Generator: HP 83640A (HP 84814A)
■ Peak Power Analyzer: HP 8990A
■ Average Power Meters (2): HP 437B
■ Standards Lab Calibrated Splitter: HP 11760S K03 (HP 84812A,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,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,only)
- Average Sensor: HP 8485A (HP 84813A,only)
- Average Sensor: HP 8487A (HP 84814A,only)

Note

Filter(s) 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 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 8990A 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 ± 0.005 mW.

5. Record in Table 6-2 data table the average power, P_{std} and P_{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 8990A 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 ⓘ 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 mW.

14. Record in Table 6-2 the reference power meter
    reading (P'_{ref}) and the peak analyzer reading (P_{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:

Γ_{std} Γ_{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

Γ, 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 Γ_{sp} and $\angle\Gamma_{sp}$ are from the standards laboratory calibration report for the splitter.
- The values Γ_{std} and $\angle\Gamma_{std}$ are from the standards laboratory calibration report for the standard sensor.
- The values Γ_{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 Table

Freq. (GHz)	Γ_{sp}	$\angle\Gamma_{sp}$	Γ_{std}	$\angle\Gamma_{std}$	Γ_{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 8990A 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
```
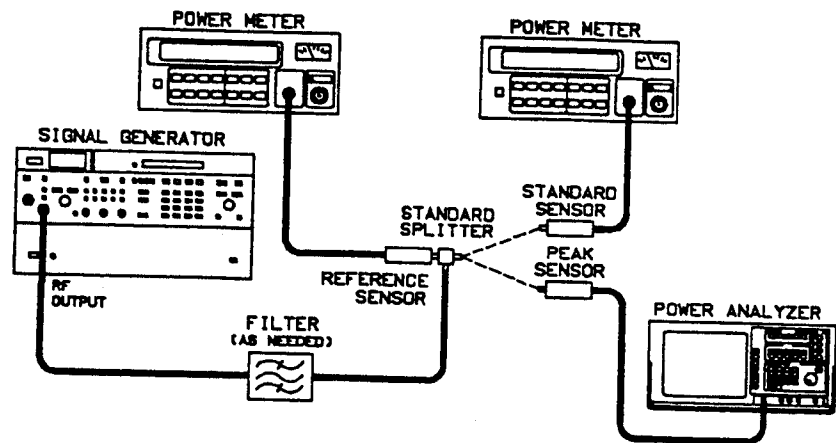
Power Variation Testing

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 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 μW $\pm$ 5 μW

6. Record in Table 6-4 the average power, P_{std} and P_{ref}, as measured by the standard sensor and the reference sensor, respectively.

2 mW to 10 mW Test with Standard Sensor

7. Adjust the signal generator power level until the reference power meter read (2 mW to 10 mW$\pm$ 0.05 mW).

8. Record in Table 6-5 the average power, P_{std} and P_{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 8990A 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 μW $\pm$ 5 μW

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$_{dut}$).

2 mW Test with Peak Sensor

17. Adjust the signal generator power level you set in step 7.

18. Press $\boxed{\text{AUTOSCALE}}$.

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 6-2. Calibration Factor at Calibration Frequencies Data Table

Freq. (GHz)	Γ_{sp}	$\angle\Gamma_{sp}$	Γ_{std}	$\angle\Gamma_{std}$	Γ_{dut}	$\angle\Gamma_{dut}$	P_{std} (mW)	P_{ref} (mW)	P_{dut} (mW)	P'_{ref} (mW)	Cf (%)

Table 6-3. Non-Calibration Frequency Data Table

Freq. GHz	Γ_{sp}	$\angle\Gamma_{sp}$	Γ_{std}	$\angle\Gamma_{std}$	Γ_{dut}	$\angle\Gamma_{dut}$

Table 6-4. 100 μW Power Level Data Table

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

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

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