Keysight W8486A Power Sensor

Operating Manual

KEYSIGHT TECHNOLOGIES

Notices

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A CAUTION notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

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A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

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Warranty Service

For warranty service or repair, this product must be returned to a service facility designated by Keysight. For products returned to Keysight for warranty service, the Buyer shall prepay shipping charges to Keysight and Keysight shall pay shipping charges to return the product to the Buyer.However, the Buyer shall pay all shipping charges, duties, and taxes for products returned to Keysight from another country.

Limitation of Warranty

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

The design and implementation of any circuit on this product is the sole responsibility of the Buyer. Keysight does not warrant the Buyer's circuitry or malfunctions of Keysight products that result from the Buyer's circuitry. In addition, Keysight does not warrant any damage that occurs as a result of the Buyer's circuit or any defects that result from Buyer-supplied products.

To the extent allowed by local law, Keysight makes no other warranty, expressed or implied, whether written or oral with respect to this product and specifically disclaims any implied warranty or condition of merchantability, fitness for a particular purpose or satisfactory quality.

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To the extent allowed by local law, the remedies provided herein are the Buyer's sole and exclusive remedies. Keysight shall not be liable for any direct, indirect, special, incidental, or consequential damages (including lost profit or data), whether based on warranty, contract, tort, or any other legal theory.

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General Safety Information

Read the information below before using this instrument.

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards for design, manufacture, and intended use of the instrument. Keysight Technologies assumes no liability for the customer's failure to comply with these requirements.

WARNING

BEFORE CONNECTING THE POWER SENSOR TO OTHER INSTRUMENTS, ensure that all instruments are connected to the protective (earth) ground. Any interruption of the protective earth grounding will cause a potential shock hazard that could result in personal injury.

CAUTION

- Use the device with the cables provided.
- Repair or service that is not covered in this manual should only be performed by qualified personnels.

Operating Environment

The operating environment for the power sensors should be within the following limits:

Environmental condition	Requirement
Temperature	0 °C to 55 °C
Relative humidity	< 95%
Altitude	< 4550 meters (15 000 feet)

Operating Precautions

CAUTION

If the following energy and power levels are exceeded, the power meter system may be damaged.

- Maximum Average Power: 200 mW
- Maximum Peak Power: 40 W

Connect the power sensor by turning only the nut on the type-N connector. Damage can occur if torque is applied to the power sensor body. The waveguide flanges can be damaged if the flange screws are over-tightened. Do not fully tighten one flange screw without tightening the one opposite. First insert screws and tighten until finger tight. If you are using the hex ball driver, hold the driver between thumb and forefinger while incrementally tightening screws opposite each other until reaching a maximum torque of 60 inch-ounces (0.42 N × m).

Use the plastic flange cover to protect the waveguide connector from dirt and mechanical damage whenever it is not in use. Any burn, dents or dirt on the flange or waveguide surface will increase the SWR and change the Cal Factor.

The type-N connector plastic bead deteriorates when contacted by any chlorinated or aromatic hydrocarbons such as acetone, trichlorethylene, carbon tetrachloride, benzene, etc. Clean the connector face with a cotton swab saturated in isopropyl alcohol.

Regulatory Markings

	The CE mark is a registered trademark of the European Community. This CE mark shows that the product complies with all the relevant European Legal Directives.		This instrument complies with the WEEE Directive (2002/96/EC) marking requirement. This affixed product label indicates that you must not discard this electrical or electronic product in domestic household waste.

Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC

This instrument complies with the WEEE Directive (2002/96/EC) marking requirement. This affixed product label indicates that you must not discard this electrical or electronic product in domestic household waste.

Product category:

With reference to the equipment types in the WEEE directive Annex 1, this instrument is classified as a “Monitoring and Control Instrument” product.

The affixed product label is as shown below.

Do not dispose in domestic household waste.

To return this unwanted instrument, contact your nearest Keysight Service Center, or visit http://about.keysight.com/en/companyinfo/environment/takeback.shtml for more information.

Sales and Technical Support

To contact Keysight for sales and technical support, refer to the support links on the following Keysight websites:

– www.keysight.com/find/powersensors
(product-specific information and support, software and documentation updates)

– www.keysight.com/find/assist
(worldwide contact information for repair and service)

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List of Tables

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1 Introduction

General Information

This manual contains information about initial inspection and operation of the W8486A power sensor.

Instruments Covered by Manual

These instruments have two-part serial numbers which is in the form 0000A0000. The first four digits and the letter comprise the serial number prefix. The last five digits form a sequential suffix which is unique to each instrument. The contents of this manual apply directly to instruments having the serial number prefix 3139A and above.

Manual Changes Supplement

An instrument manufactured after the printing of a manual may have a serial number prefix not listed above. Unlisted serial number prefixes indicate that the manual for such an instrument has been amended with a distinctive yellow *Manual Changes* supplement containing updated technical information.

Manual Changes supplements may also provide corrections to errors in manuals. To keep the instrument manual as current and accurate as possible, Keysight recommends that you periodically obtain the latest *Manual Changes* supplement. *Manual Changes* supplements are keyed to a manual's print date and part number.

For information concerning a serial number prefix not listed on this manual or in the *Manual Changes* supplement, contact your nearest Keysight office.

Warranty

The power sensor is warranted and certified. Do not open the power sensor. Any attempt to disassemble the power sensor will void warranty.

Description

The W8486A is a diode power sensor. It measures power levels in a range from –30 dBm to +20 dBm. (Specifications for the power sensor are in Chapter 3, "Specifications".) The W8486A measures at frequencies from 75 GHz to 110 GHz.

The power is determined from the ac voltage developed across the 50 ohm load from the microwave source. The diodes convert this ac voltage to dc. The dc voltage produced is the square of the ac voltage. The dc voltage thus generated is a very low-level voltage and requires amplification before it can be transferred on standard cables to the power meter.

The amplification is provided by an input amplifier assembly which consists of a chopper (sampling gate) and an input amplifier. The dc voltage is routed to the chopper circuit which converts the low-level dc voltage to an ac voltage. The chopper is driven by a 220 Hz square wave generated by the power meter. The result is an ac output signal proportional to the dc input. The ac signal is then amplified by the input amplifier. The relatively high-level ac signal output can now be routed by standard cables.

NOTE The W8486A power sensor is compatible with the Keysight 435B, 436A, 437B, and 438A power meters.

In application, the power sensor is connected between a microwave source and a compatible power meter. The power sensor provides a matched load for the microwave source for very low SWR. The power meter indicates the power dissipated in the load in µW, mW or in dBm.

CAUTION Do not disassemble the power sensor. The power sensor is extremely static sensitive and can be easily damaged.

Accessories

Included is a hex ball driver plus the waveguide mounting screws. Refer to Figure 1-1 for a visual check of what should be included with your power sensor.

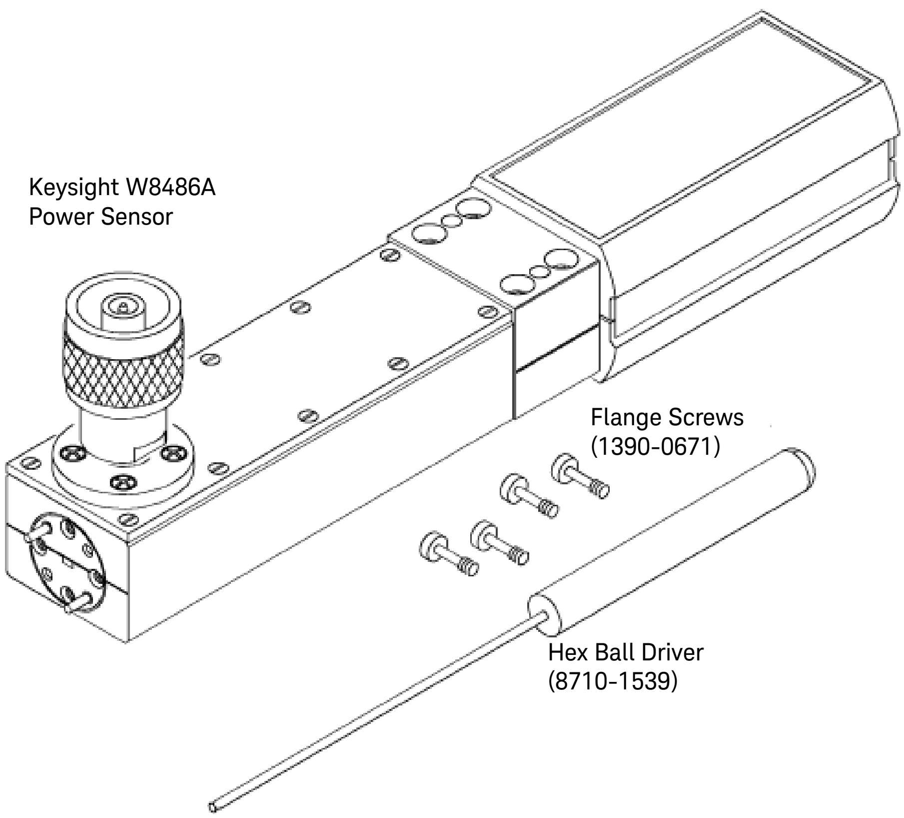

Figure 1-1 W8486A power sensor with accessories and hardware

Installation

Initial Inspection

Inspect the shipping container for damage. If the shipping container or packaging material is damaged, it should be kept until the contents of the shipment have been checked mechanically and electrically. If there is mechanical damage or if the instrument does not pass the performance tests, notify the nearest Keysight office. Keep the damaged shipping materials (if any) for inspection by the carrier and a Keysight representative.

Interconnections

The W8486A power sensor has two inputs: a type-N connector and a WR-10 waveguide flange. During calibration, the type-N connector is connected to the calibration port of the power meter. During measurement, the waveguide flange is connected to the device under test.

CAUTION

Connect the power sensor by turning only the nut on the type-N connector. Damage can occur if torque is applied to the power sensor body.

The waveguide flanges can be damaged if the flange screws are over-tightened. Do not fully tighten one flange screw without tightening the one opposite. First insert screws and tighten until finger tight. If you are using the hex ball driver, hold the driver between thumb and forefinger while incrementally tightening screws opposite each other until reaching a maximum torque of 60 inch-ounces (0.42 N x m).

Use the plastic flange cover to protect the waveguide connector from dirt and mechanical damage whenever it is not in use. Any burn, dents or dirt on the flange or waveguide surface will increase the SWR and change the Cal Factor.

Refer to the power meter operating and service manual for interconnecting instructions.

CAUTION

Connect the power sensor by turning only the nut on the type-N connector. Damage can occur if torque is applied to the power sensor body.

Storage and Shipment

Environment

The instruments should be stored in a clean, dry environment. The following limitations apply to both storage and shipment:

Environmental conditions	Requirements
Temperature	–40 to +55 °C
Relative humidity	< 95% @ 40 °C
Altitude	< 15,300 meters (25 000 feet)

Original Packaging

Containers and materials identical to those used in factory packaging are available through Keysight offices. If the instrument is being returned to Keysight for servicing, attach a tag indicating the type of service required, return address, model number, and serial number.

Also, mark the container FRAGILE to assure careful handling. In any correspondence, refer to the instrument by model number and serial number.

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2 Making Measurements

Operation

Power Meter Calibrations

The procedure of calibrating one power meter may be different for another power meter. Follow the calibration directions given in your power meter manual.

Power Measurements

To correct for varying responses at different frequencies a cal factor chart is included on the power sensors. To use the cal factor at the frequency of interest, adjust the power meter's CAL FACTOR control according to the instructions in the power meter's operating and service manual.

If you are using a 435B or 436A, the minimum cal factor setting is 85% and the maximum is 100%. If the cal factor setting for your frequency of interest is below the meter's minimum or above the meter's maximum, set the cal factor control to 100%, and divide the reading in watts units by the decimal equivalent of the cal factor. For example, if the cal factor is 75%, divide the reading by 0.75. (This will result in a larger value of power than that displayed by the meter.)

If the cal factor is 104%, divide the reading by 1.04. (This will result in a smaller value of power than that displayed by the meter.)

If reading in dBm, use the chart in Table 2-1 to convert the cal factor to dB and add this value to the reading. Interpolate for values between those shown. As above, the cal factor control should be set to 100%. If the cal factor is 75%, add 1.25 dB to the displayed value. On the other hand, if the cal factor is 104%, subtract 0.170 from the displayed reading.

NOTE

The above procedure has eliminated some mathematical steps, the following formula may be of some use:

Correction dB = Reading dBm –10 x Log10 Cal Factor (decimal).

Table 2-1 Cal factor to dB conversion table

Cal factor	dB	Cal factor	dB	Cal factor	dB
70%	1.55	79%	1.02	103%	–0.128
71%	1.49	80%	0.97	104%	–0.170
72%	1.43	81%	0.92	105%	–0.212
73%	1.37	82%	0.86	106%	–0.253
74%	1.31	83%	0.81	107%	–0.294
75%	1.25	84%	0.76	108%	–0.334
76%	1.19	85%	0.71	109%	–0.374
77%	1.14	101%	–0.043	110%	–0.414
78%	1.08	102%	–0.086		

The sensitivity of the power sensor is influenced by ambient temperature. The sensor should be recalibrated after each change in temperature to obtain the most accurate results. Typical temperature sensitivity variations are shown in Figure 2-1.

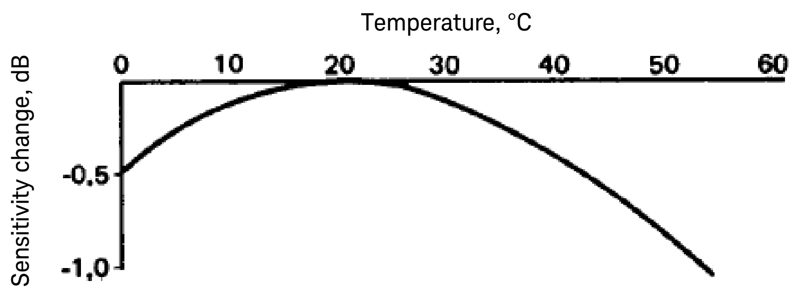

Figure 2-1 Typical influence of temperature on sensitivity

Operating Instructions

To operate the power sensor, refer to the operating instructions in Section III of the power meter operating and service manual.

NOTE

If having an open RF connection on your system is a concern, terminate the sensor type-N calibration port with a 50W load.

Correction dB = Reading dBm –10 x Log10 Cal Factor (decimal).

Modulation Effects

When measuring microwave sources that are modulated at the chopper frequency (nominally 220 Hz), or at the first or second harmonic or submultiples of the chopper frequency, beat notes will occur. Unless these beat notes are exactly the chopper frequency, they can usually be eliminated by averaging since the amplitudes are plus and minus the actual power. These frequencies may also be avoided by changing the modulation frequency slightly, if possible.

If you are using a 437B power meter, select a manual filter setting of at least 128 (as displayed on power meter) to minimize beat note interference. To minimize beat note interference using a 438A power meter select a filter number of at least 7.

Calibration Factor (CF) and Reflection Coefficient (Rho)

The CAL FACTOR compensates for the frequency response of the sensor. CAL FACTOR and reflection coecient data are provided on a label attached to the sensor cover. Probable uncertainties are calculated using the root sum of the squares (RSS) method. To use CAL FACTOR data during power measurements, see “Power Measurements” on page 24 in this manual.

Reflection Coefficient (Rho, or ρ) relates to SWR according to the following formula:

$$SWR = \frac{(1+\rho)}{(1-\rho)}$$

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3 Specifications

Specifications

For the characteristics and specifications of the W8486A Power Sensor, refer to the data sheet at https://www.keysight.com/us/en/assets/7018-04203/data-sheets/5991-3676.pdf.

4 Service

KEYSIGHT TECHNOLOGIES

Performance Test

This section does not establish SWR test procedures since there are several test methods and different equipment available for testing the SWR or reflection coefficient. Therefore, the actual accuracy of the test equipment, all source match corrections, and all harmonics must be accounted for when measuring against instrument specifications to determine a pass or fail condition.

To measure the SWR across the waveguide band, use a directional coupler and detector selected for the band of interest. The directional coupler should have a directivity greater than 40 dB. The detector should have greater than 0.4 mV/μW sensitivity and should be calibrated with a rotary vane attenuator with an accuracy of 2%. Incident power should be less than –20 dBm. A convenient source is a frequency multiplier driven by an Keysight 8350B and Keysight 83594A.

To check the calibration factor, the power sensor should be compared with another recently calibrated power sensor. The source should be leveled with a reference coupler that has low SWR and high directivity to monitor or level the incident power (which should be less than –30 dBm).

For reflection measurements, we suggest *Application Note 183 "High Frequency Swept Measurements"* For calibration factor and error analysis, we suggest *Application Note 64-1 "Fundamentals of RF and Microwave Power Measurements"*

NOTE **The true position of the holes relative to each other are held to a diameter tolerance of 0.0254 mm (0.001). The holes are held to 1.664 mm (0.0655) minimum diameter while the pins are held to 1.61 mm (0.0634) maximum diameter.**

Zero Set Performance Verification

The performance verification is carried out to verify that a minimal amount of residual offset error is present after zeroing has been performed. The offset error is caused by contamination from several sources including the noise of the device-under-test (DUT) itself. Zero set is the difference between the power levels indicated by the DUT, after executing zeroing and the true zero power. Ideally, the difference should be zero.

The performance test requires a compatible Keysight power meter with the DUT, and a computer with the Keysight IO Libraries Suite installed.

Recommended power meter	:	EPM (N1913A/ 14A, E4418B/ 19B), EPM-P (E4416A/ 17A), and P-series (N1911A/ 12A) power meters

Procedure

1 Connect the DUT (V/W8486A) to the power meter as shown in Figure 4-1.

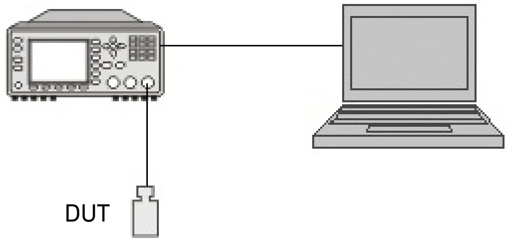

Figure 4-1 Zero set performance verification equipment setup

2 Warm up the DUT for approximately 30 minutes.
3 Launch the Interactive IO on the Keysight IO Libraries Suite to send SCPI commands to the DUT.
4 Reset the power meter to a known state by sending "`*RST`" command, followed by "`SYST:PRES`" command to pre-set the meter's output to default value.
5 Connect the DUT to the power meter 1 mW calibrator and perform zeroing for the DUT by sending "`CAL:ZERO:AUTO ONCE`". (Use the recommended adapter for respective model.)
6 Perform calibration for the DUT by sending "`CAL:AUTO ONCE`".
7 Set the frequency of the DUT to 50 MHz by sending "`FREQ 50MHz`".
8 Enable auto-averaging for the DUT by sending "`AVER:COUN:AUTO ON`".
9 Change the power measurement unit of the DUT to watt by sending "`UNIT:POW W`".
10 Disconnect the DUT from the power meter 1 mW calibrator.
11 Perform zeroing for the DUT by sending "`CAL:ZERO:AUTO ONCE`".
12 Set the DUT to a single trigger mode by sending "`INIT:CONT OFF`".
13 Read the noise level of the DUT by sending "`READ`", and then record the reading.
14 Repeat step 13 for 10 times and then calculate the mean value of the readings.
15 Compare the calculated mean value to the system specification. If the test fails, refer to "Replaceable Parts" on page 34.

Power linearity performance verification

The power linearity performance verification measures the relative linearity error of the V/W8486A. All measurements are performed at 50 MHz. The reference power level for the linearity measurement is 0 dBm for the V8486A and W8486A.

This performance verification requires the following equipment:

– signal generator (N5182A)
– thermocouple-based average power sensor, as a reference sensor (N8481A/5A/7A)
– power meter (E4416/7A)
– power splitter (11667A)
– amplifier
– step attenuators (8494H and 8496H)

– attenuator/switch driver (11713B)

Procedure

1 Turn on the signal generator and power meter (with the reference sensor connected). Connect the DUT (V/W8486A) to the power meter. Allow them to warm up for approximately an hour.

2 Zero and calibrate the DUT using the reference sensor with the power meter.

3 Connect the power splitter to the RF output of the signal generator. The equipment setup is as shown in Figure 4-2.

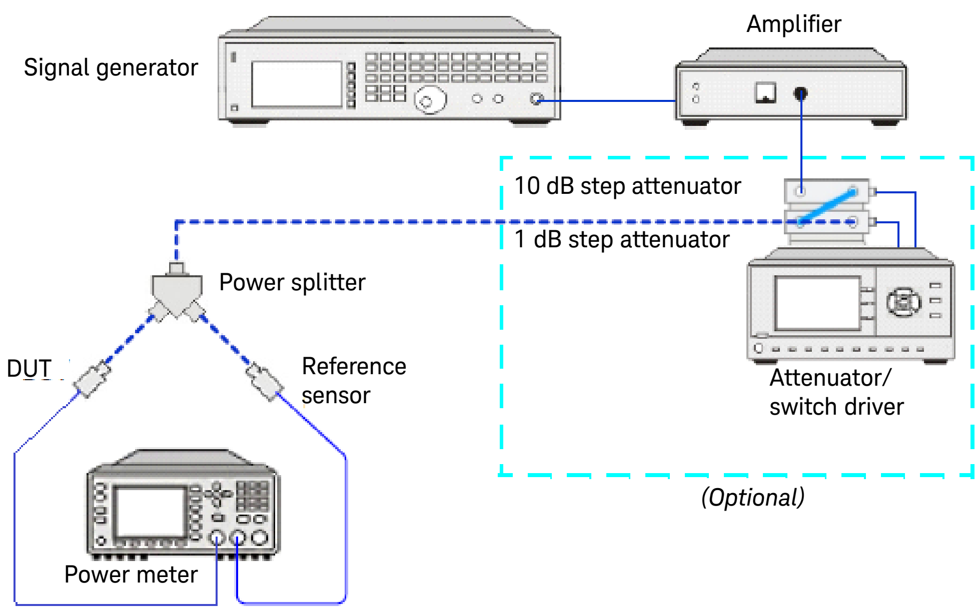

Figure 4-2 Power linearity performance verification equipment setup

4 Set the continuous wave signal frequency of the signal generator, DUT, and reference sensor to 50 MHz. Set DUT to AVERAGE ONLY mode.

5 Start tuning the signal generator and/or attenuator/switch driver (optional) until the DUT measures the power level as close as 0 dBm. Record the values as P_{DUT} at 0 dBm and P_{ref} at 0 dBm.

CAUTION **Do not exceed the maximum input power (27 dBm) of the power splitter to avoid damage to the power splitter.**

6 Record the power measured by the power meter for both DUT and reference power sensor as P_{DUT} and P_{ref} respectively.

7 Normalize both P_{DUT} and P_{ref} to the power measured at 0 dBm, based on the following equation.

Normalization

= Measured Power ($P_{DUT/ref}$) - Measured Power at 0 dBm ($P_{DUT/ref\ at\ 0\ dBm}$)

8 Calculate the linearity error of the DUT for the power level using the following equations.

$$\text{Linearity error (dB)} = [P_{DUT}]_{\text{norm to 0 dBm}} - [P_{ref}]_{\text{norm to 0 dBm}}$$

$$\text{Linearity error (\%)} = \left[\text{Antilog}\left(\frac{[P_{DUT}]_{\text{norm to 0 dBm}} - [P_{ref}]_{\text{norm to 0 dBm}}}{10}\right) - 1\right] \times 100$$

9 Compare and record the calculated linearity error against the system linearity error specifications.

10 Repeat step 6 to step 9 by sweeping through the warranted power levels for power linearity test as in the datasheet at 50 MHz.

11 Repeat step 5 to step 11 for normal mode. If the verification fails, refer to “Repair and Adjustments” on page 34.

12 The linearity system specification is calculated using the root sum of the squares (RSS) method by considering the error caused from reference sensor used and the DUT error in the system at 50 Mhz, and the error can be found in their respective datasheet. The RSS error specification calculation is computed by using the following equation:

$$\text{System linearity error specification} = \pm\sqrt{\text{DUT error}^2 + \text{Ref sensor error}^2}$$

Example for the DUT measured at 50 Mhz, 20 dBm:

– DUT used is V8486A

– Reference sensor used is N8481A

$$\text{System linearity error specification} = \pm\sqrt{(2\%)^2 + (0.8\%)^2} = \pm 2.07\%$$

Replaceable Parts

The hex ball driver, the flange covers, and the hardware are the only replaceable parts. The part numbers are listed in Figure 1-1.

Repair and Adjustments

Do not attempt to repair or adjust the power sensor. Due to the extreme static sensitivity of the power sensor, customer repair is not recommended. If your power sensor should fail or need calibration, return it to Keysight.

CAUTION **Do not disassemble the power sensor. The power sensor is extremely static sensitive and can be easily damaged. If the power sensor shows evidence of attempted customer repair, the warranty may be voided.**

This information is subject to change without notice. Always refer to the English version at the Keysight website for the latest revision.

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