

# Keysight V8486A Power Sensor

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Keysight Technologies certifies that this product met its published specifications at the time of shipment. Keysight further certifies that its calibration measurements are traceable to the United States National Institute of Standard and Technology (formerly National Bureau of Standards), to the extent allowed by that organization's calibration facility, and to the calibration facilities of other International Standards Organization members.

## Warranty

This Keysight Technologies instrument product is warranted against defects in material and workmanship for a period of 3 years from date of shipment. During the warranty period, Keysight Technologies 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 Keysight Technologies. Buyer shall prepay shipping charges to Keysight Technologies and Keysight Technologies shall pay shipping charges, duties, and taxes for products returned to Keysight Technologies from another country. Keysight Technologies warrants that its software and firmware designated by Keysight Technologies for use with an instrument will execute its programming instructions when properly installed on that instrument. Keysight Technologies does not warrant that the operation of the instrument, or firmware will be uninterrupted or error free.

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## Safety Considerations

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.

# Environmental Conditions

The V8486A is designed for indoor use and in an area with low condensation. The table below shows the general environmental requirements for this instrument.

Environmental condition	Requirement
Temperature	Operating condition - 0 °C to 55 °C
	Storage condition - -40 °C to 70 °C
Humidity	Operating condition - Up to 95%
	Storage condition - Up to 95% RH at 40°C (non-condensing)
Altitude	Operating condition - Up to 4550 meters
	Storage condition - Up to 7,600 meters

## 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/waveguidepowersensors](http://www.keysight.com/find/waveguidepowersensors)  
(product-specific information and support, software and documentation updates)
- [www.keysight.com/find/assist](http://www.keysight.com/find/assist)  
(worldwide contact information for repair and service)

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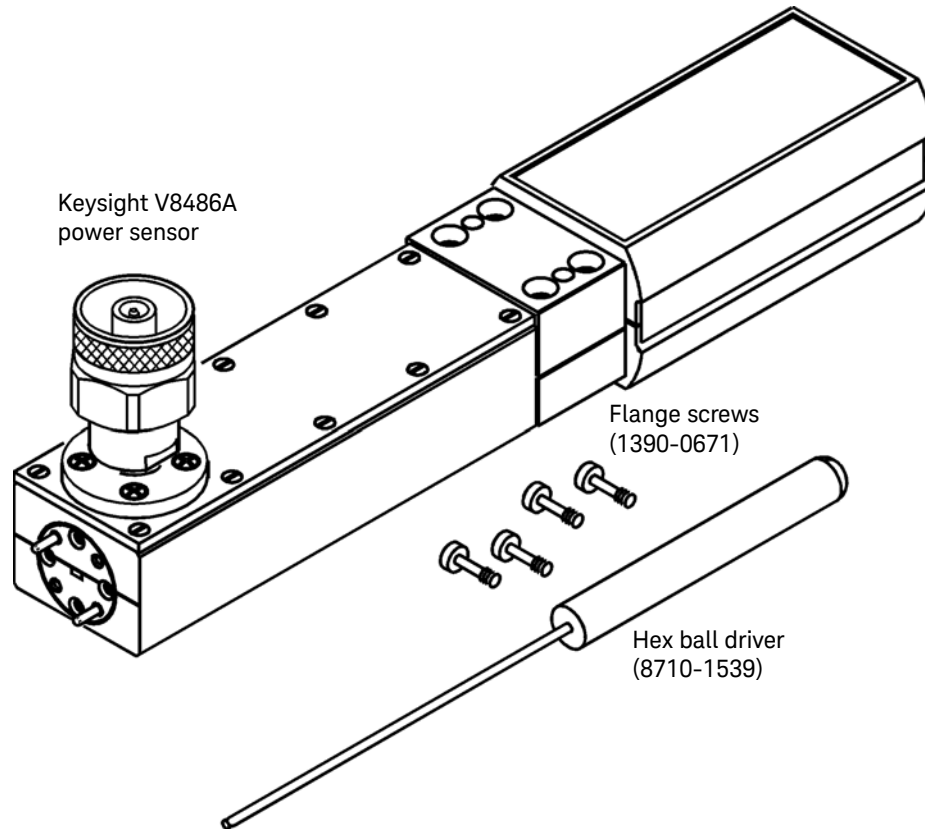
# 1 Introduction

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This chapter provides an overview of the V8486A power sensor and its general information.

## General Information

This User's guide contains information about initial inspection and operation of the Keysight V8486A power sensor.



**Figure 1-1** Keysight V8486A power sensor with accessories and hardware

## Warranty

The power sensor is warranted and certified as indicated on the last page of this manual. Do not open the power sensor. Any attempt to disassemble the power sensor will void warranty.

## Description

The Keysight V8486A is a diode-based power sensor. It measures power levels in a range from  $-30$  dBm to  $+20$  dBm. (Specifications for the power sensor are in the data sheet) The Keysight V8486A measures at frequencies from 50 GHz to 75 GHz.

The power is determined from the ac voltage developed across the waveguide termination from the microwave source. The diodes convert this ac voltage to dc. The dc voltage produced is proportional to 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 via the sensor cable 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 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 Keysight V8486A power sensor is compatible with the following power meters:

Keysight 435B	Keysight E1416A
Keysight 436A	Keysight E4418A/B
Keysight 437B	Keysight E4419A/B
Keysight 438A	Keysight 70100A

To obtain optimum accuracy for power measurements above +10 dBm, when used with the Keysight E4418A and Keysight E4419A power meters, a firmware upgrade will be required. Refer to your Keysight E4418A and Keysight E4419A power meter's user's guide for instructions on how to obtain the revision of the firmware currently installed in the unit. The firmware revision required is A1.03.00 (or above) for the Keysight E4418A and A2.03.00 (or above) for the Keysight E4419A. Contact your local Keysight Technologies Sales and Service Office for more information.

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  $\mu\text{W}$ , 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.

## Recommended calibration interval

Keysight Technologies recommends a one-year calibration cycle for the V8486A power sensor.

## 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 Technologies office. Keep the damaged shipping materials (if any) for inspection by the carrier and a Keysight Technologies representative.

### Interconnections and calibration

The Keysight V8486A power sensor has two inputs: a Type-N connector and a 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 0.42 N x m.

---

Use the protective packaging provided with the power sensor to protect it from dirt and mechanical damage whenever it is not in use. Any burrs, 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.



## Storage and Shipment

### Original packaging

Containers and materials identical to those used in factory packaging are available through Keysight Technologies offices. If the instrument is being returned to Keysight Technologies 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 General Operation

Operation 20

This chapter provides the V8486A general operation information on how to check and prepare your instrument for operation.

## Operation

### Operating precautions

#### 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 and cause damage to the power sensor.

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#### 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: 40W<sup>[a]</sup>
- 

[a] 10 micro-second pulse, 0.5% duty cycle or equivalent such that 200 mW maximum average power and 40W peak power are not exceeded.

The power sensor has a precision machined V-band waveguide interface. The size and position of the aperture, the alignment holes and pins, and the flatness of the mating faces are all very tightly controlled. Refer to [Figure 2-1](#).

In order to get the best possible measurement results the mating part must be of similar quality. Connection to a V-band waveguide component in which the interface dimensions are not accurately controlled can lead to increased SWR, inaccurate Cal Factor correction, and/or repeatability problems. In addition, connections to a well-manufactured but dirty part can lead to any of the above measurement problems. Conversely, always insuring connections to parts with clean, high-quality waveguide interfaces will lead to accurate power measurements over the life of the product.

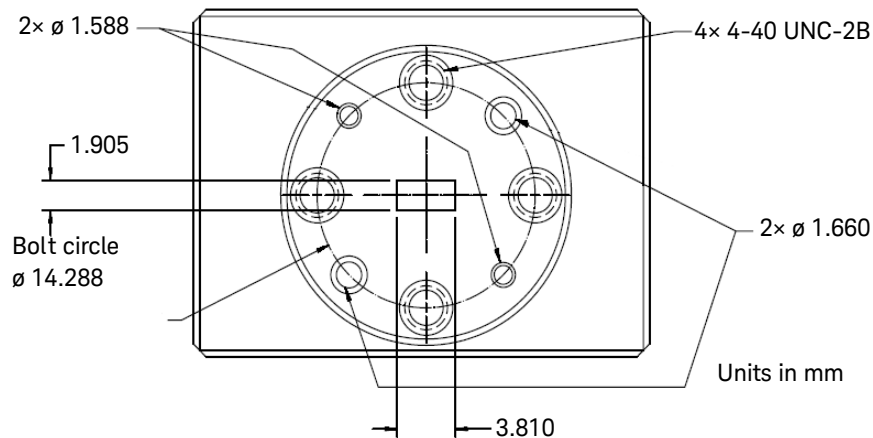
#### CAUTION

**Connection to a V-band waveguide component with a dirty, or damaged flange (for example loose particulates, raised metal burrs or bent alignment pins) can damage the precision interface of the power sensor. Always inspect and clean the mating part prior to connection.**

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Use the protective packaging provided with the sensor 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.



**Figure 2-1** Precision V-band interface on the front of the power sensor

## Power meter calibrations

The procedure for calibration may be different for each compatible 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. This will automatically correct the power readings.

If you are using a Keysight 435B or Keysight 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 0.17 dB from the displayed reading.

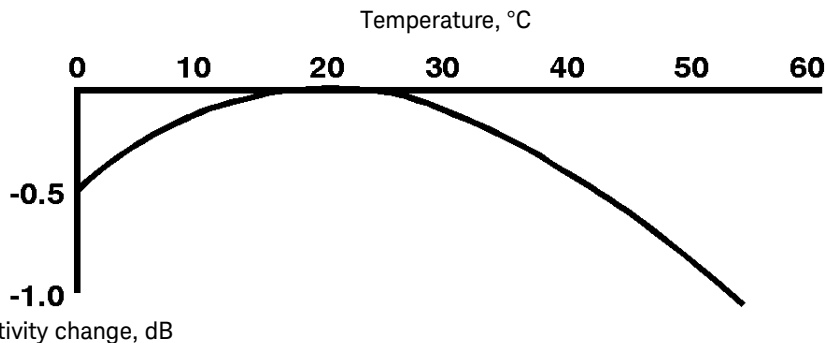
### NOTE

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

$$\text{Correct dBm} = \text{Reading dBm} - 10 \times \text{Log}_{10} \{ \text{Cal Factor (decimal)} \}.$$

**Table 2-1 Cal factor**

<b>Cal factor</b>	<b>dB</b>	<b>Cal factor</b>	<b>dB</b>	<b>Cal factor</b>	<b>dB</b>
70%	1.549	85%	0.706	115%	-0.607
71%	1.487	101%	-0.043	116%	-0.645
72%	1.427	102%	-0.086	117%	-0.682
73%	1.367	103%	-0.128	118%	-0.719
74%	1.308	104%	-0.170	119%	-0.755
75%	1.249	105%	-0.212	120%	-0.792
76%	1.192	106%	-0.253	121%	-0.828
77%	1.134	107%	-0.294	122%	-0.864
78%	1.079	108%	-0.334	123%	-0.899
79%	1.024	109%	-0.374	124%	-0.934
80%	0.969	110%	-0.414	125%	-0.969
81%	0.915	111%	-0.453	126%	-1.004
82%	0.862	112%	-0.492	127%	-1.038
83%	0.809	113%	-0.531	128%	-1.072
84%	0.757	114%	-0.569	129%	-1.106
				130%	-1.139



**Figure 2-2** Typical influence of temperature on sensitivity

The sensitivity of the power sensor is influenced by ambient temperature. The sensor should be calibrated at the temperature of operation to obtain the most accurate results. Typical temperature sensitivity variations are shown in [Figure 2-2](#).

## Operating instructions

To operate the power sensor, refer to the operating instructions in 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 50  $\Omega$  load.

## Modulation effects

When measuring microwave sources that are modulated at the chopper frequency (nominally 220 Hz for the Keysight 43X family and 217 Hz for the Keysight E4418A/B and Keysight E4419A/B), or at the first or second harmonic or submultiples of the chopper frequency, beat notes will occur. Unless the modulation rate is exactly the chopper frequency, they can usually be eliminated by averaging since the amplitudes are centered on the actual power. These frequencies may also be avoided by changing the modulation frequency slightly, if possible.

If you are using a Keysight 437B, Keysight E4418A/B or Keysight E4419A/B Power Meter, a filter setting of 128 will minimize most beat note interference. To minimize beat note interference using a Keysight 438A Power Meter select a filter number of at least 7.

## Linearity correction

For most Keysight 8480 series power sensors the correct (A type or D type) linearity correction table is automatically selected. However, when you use the Keysight V8486A power sensor with Keysight EPM power meters, you must override the automatic selection and select the D-type correction. This procedure provides optimum accuracy when making power measurements  $>+10$ dBm. Subsequent connection of another

A-type sensor will result in a warning message stating the “Linearity Override May be Required”.

To select the linearity type to be applied:

Keysight E4418B

Press [System Inputs], Tables, Linearity ATyp DTyp.

Keysight E4419B

Press [System Inputs], Tables, A Linearity ATyp DTyp or B Linearity ATyp DTyp.

**NOTE**

For use with the Keysight E4418A and Keysight E4419A power meters, a firmware upgrade will be required. Refer to your Keysight E4418A and Keysight E4419A power meter's user's guide for instructions on how to obtain the revision of the firmware currently installed in the unit. The firmware revision required is A1.03.00 (or above) for the Keysight E4418A and A2.03.00 (or above) for the Keysight E4419A. Contact your local Keysight Technologies Sales and Service Office for further information.

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# 3 Specifications and Characteristics

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## Specifications and Characteristics

For the characteristics and specifications of the V8486A Power Sensor, refer to the data sheet at <https://www.keysight.com/us/en/assets/7018-04203/data-sheets/5991-3676.pdf>.

# 4 Service

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This chapter provides information on the V8486A performance tests and service.

## Performance Tests

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 36 dB, such as the Keysight V752C/D. The detector should have greater than 0.4 mV/ $\mu$ W 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 a Keysight 8360 B-Series swept signal generator.

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.

For calibration factor and error analysis we suggest Keysight Application Note 64-1A: Keysight literature number 5965-6630E, "*Fundamentals of RF and Microwave Power Measurements*".

### Zero set performance verification

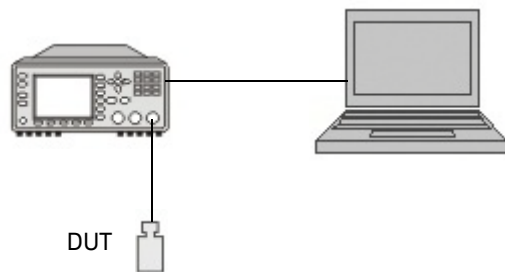
This performance verification is carried out to verify that a minimal amount of residual offset error is present after zeroing has been performed. The offset error is caused by contamination from several sources including the noise of the device-under-test (DUT) itself. Zero set is the difference between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

This 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 the 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 ["Repair and adjustments"](#) on page 32.

## Power linearity performance verification

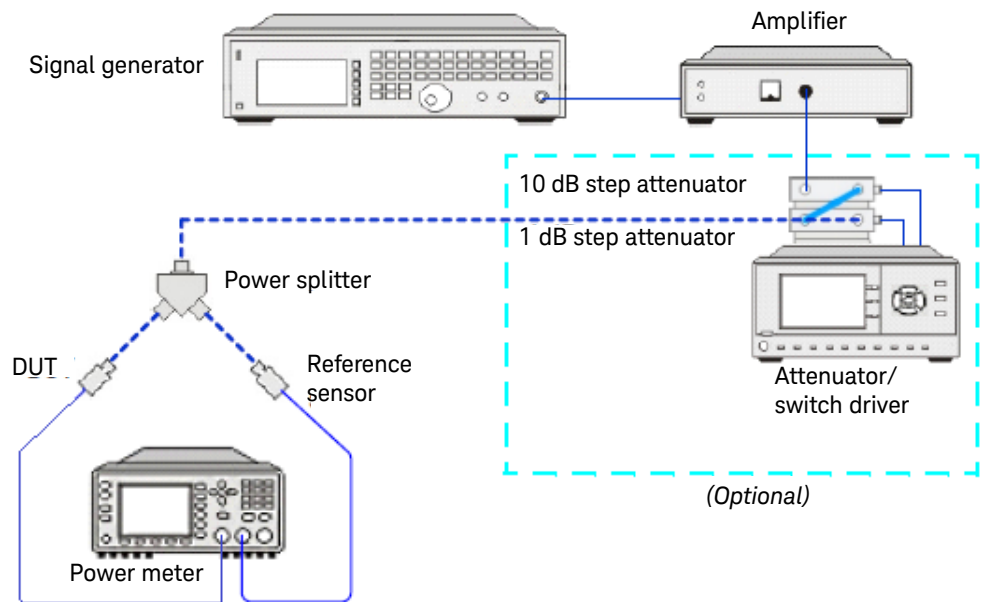
The power linearity performance verification measures the relative linearity error of the V/W8486A. All measurements are performed at 50 MHz. The reference power level for the linearity measurement is 0 dBm for the V8486A and W8486A.

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  $P_{DUT}$  as  $P_{ref}$  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.  
 Linearity error (dB) =  $[P_{DUT}]_{norm\ to\ 0\ dBm} - [P_{ref}]_{norm\ to\ 0\ dBm}$   
 Linearity error (%) =  $\left[ \text{Antilog}\left(\frac{[P_{DUT}]_{norm\ to\ 0\ dBm} - [P_{ref}]_{norm\ to\ 0\ dBm}}{10}\right) - 1 \right] \times 100$
- 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 32.
- 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. The error specification caused by the reference sensor and the DUT can be found in their respective datasheet. The RSS error specification calculation is computed by using following equation.

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

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

- DUT used is V8486A
- Reference sensor used is N8481A

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

## Replaceable Parts

The part numbers of the hex ball driver and the hardware are listed in [Figure 1-1](#). In addition, the following protective parts are replaceable:

**Table 4-1** Replaceable parts

Part number	Description	Usage
1401-0214	protective cap	Type-N connector
08486-40103	protective cover	V-band waveguide flange

There are no other replaceable parts for this product.

### 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 Technologies.

#### 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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