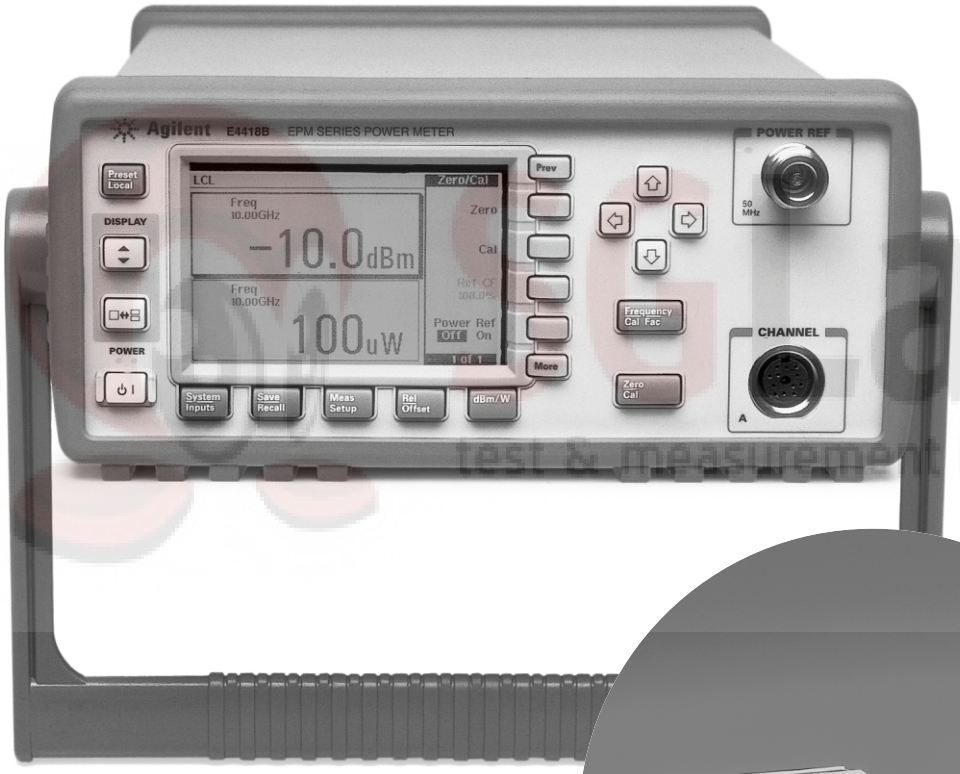
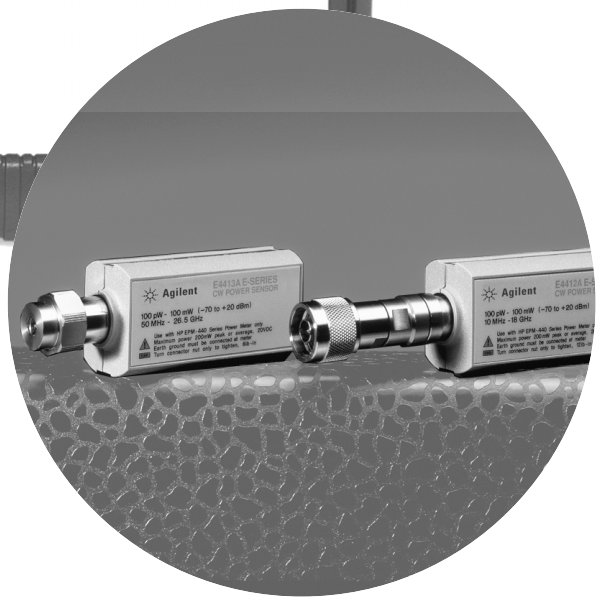
Agilent
EPM Series Power Meters
E-Series and 8480 Series Power Sensors

Data Sheet





Product specifications and characteristics

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EPM series E4418B and E4419B power meters

Specifications

Specifications describe the instrument's warranted performance and apply after a 30 minute warm-up. These specifications are valid over its operating/environmental range unless otherwise stated and after performing a zero and calibration procedure.

Supplemental characteristics

Supplemental characteristics (shown in italics) are intended to provide additional information, useful in applying the instrument by giving typical (expected), but not warranted performance parameters. These characteristics are shown in italics or labeled as "typical", "nominal" or "approximate".

For information on measurement uncertainty calculations, refer to Application Note 64-1C, "*Fundamentals of RF and Microwave Power Measurements*", literature number 5965-6380E.

Frequency range: 9 kHz to 110 GHz, sensor dependent

Power range: –70 dBm to +44 dBm (100 pW to 25 W), sensor dependent.

Power sensors: Compatible with all 8480 series and E-series sensors

Single sensor dynamic range:
90 dB maximum (E-series sensors), 50 dB maximum (8480 series sensors).

Display units:
Absolute: Watts or dBm.
Relative: Percent or dB.

Display resolution: Selectable resolution of 1.0, 0.1, 0.01, and 0.001 dB in Log mode, or 1 to 4 digits in linear mode.

Default resolution: 0.01 dB in log mode, 3 digits in linear mode.

Accuracy

Instrumentation

Absolute: ±0.02 dB (log) or ±0.5% (linear). Please add the corresponding power sensor linearity percentage from tables 7 and 10 (for the E-series sensors) and table 15 (for the 8480 series sensors).

Relative: ±0.04 dB (Log) or ±1.0% (linear). Please add the corresponding power sensor linearity percentage from table 16 (for the 8480 series sensors).

Zero set (digital settability of zero): sensor dependent (refer to table 1). For E-series sensors, this specification applies to a ZERO performed when the sensor input is not connected to the POWER REF.

Power reference

Power output: 1.00 mW (0.0 dBm). Factory set to ±0.4% traceable to the National Physical Laboratory (NPL), UK[1].

Accuracy: For two years:
±0.5% (23 ± 3°C)
±0.6% (25 ± 10°C)
±0.9% (0 to 55°C)

Frequency: 50 MHz nominal

SWR: 1.06 maximum
(1.08 maximum for Option 003)

Connector type: Type N (f), 50 Ω

Table 1

Model	ZERO SET
8481A, 8482A, 8483A, 8485A, 8487A, R8486A, Q8486A,	±50 nW
8481B, 8482B	±50 µW
8481D, 8485D, 8487D	±20 pW
8481H, 8482H	±5 µW
R8486D, Q8486D	±30 pW
V8486A, W8486A	±200 nW
E4412A, E4413A	±50 pW
E9300A, E9301A,E9304A [2]	±500 pW
E9300B, E9301B [2]	±500 nW
E9300H, E9301H [2]	±5 nW

1. National metrology institutes of member states of the Metre Convention, such as the National Institute of Standards and Technology in the USA, are signatories to the ComitÈ International des Poids et Mesures Mutual Recognition Arrangement. Further information is available from the Bureau International des Poids et Mesures, at **http://www.bipm.fr/**

2. Specification applies to the low power path 15% to 75% relative humidity.

Supplemental characteristics

Power reference

Frequency: 50 MHz nominal.
SWR: 1.05 maximum.
Connector: Type N (f), 50 Ω.

Measurement speed

Three measurement speed modes, over the GPIB, are available as shown, along with the typical maximum measurement speed for each mode.

With the E4418B power meter

Normal: 20 readings/second
x2: 40 readings/second
Fast: 200 readings/second

With the E4419B, the measurement speed is reduced, for example, with both channels in FAST mode, the typical maximum measurement speed is 100 readings/second.

Fast mode is for E-series sensors only.

Maximum measurement speed is obtained using binary output and in free run trigger mode.

Zero drift of sensors: Sensor dependent, refer to table 2. For E9300 sensors, refer to table 12 for complete data.

Table 2

Model	Zero drift [1]	Measurement noise[2]
8481A, 8482A, 8483A, 8485A, 8487A, R8486A, Q8486A	< ±10 nW	< 110 nW
8481B, 8482B	< ±10 µW	< 110 µW
8481D, 8485D, 8487D	< ±4 pW	< 45 pW
8481H, 8482H	< ±1µW	< 10 µW
R8486D, Q8486D	< ±6 pW	< 65 pW
V8486A, W8486A	< ±40 nW	< 450 nW
E4412A, E4413A	< ±15 pW	< 70 pW
E9300A, E9301A, E9304A[3]	< ±150 pW	< 700 pW
E9300B, E9301B[3]	< ±150 nW	< 700 nW
E9300H, E9301H[3]	< ±1.5 nW	< 7 nW

1. Within 1 hour after zero set, at a constant temperature, after a 24-hour warm-up of the power meter.
2. The number of averages at 16 for normal mode and 32 for x2 mode, at a constant temperature, measured over a one minute interval and two standard deviations. For E-series sensors, the measurement noise is measured within the low range. Refer to the relevant sensor manual for further information.
3. Specification applies to the low power path, 15% to 75% relative humidity.

Measurement noise: Sensor dependent, refer to table 2 and table 3. For E9300 sensors, refer to table 12.

Effects of averaging on noise: Averaging over 1 to 1024 readings is available for reducing noise. Table 2 provides the measurement noise for a particular sensor with the number of averages set at 16 (for normal mode) and 32 (for x2 mode). Use the noise multiplier, for the appropriate mode (normal or x2) and number of averages, to determine the total measurement noise value.

Example:
8481D power sensor, normal mode, number of averages = 4.

Measurement noise calculation:
(< 45 pW x 2.75) = < 121 pW.

Table 3

Number of averages	1	2	4	8	16	32	64	128	256	512	1024
Noise multiplier (normal mode)	5.5	3.89	2.75	1.94	1	0.85	0.61	0.49	0.34	0.24	0.17
Noise multiplier (x2 mode)	6.5	4.6	3.25	2.3	1.63	1	0.72	0.57	0.41	0.29	0.2

EPM series E4418B and E4419B power meters

Settling time [1]

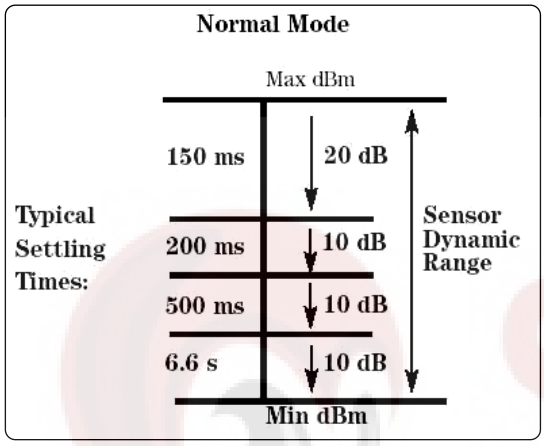
For 8480 series sensors:

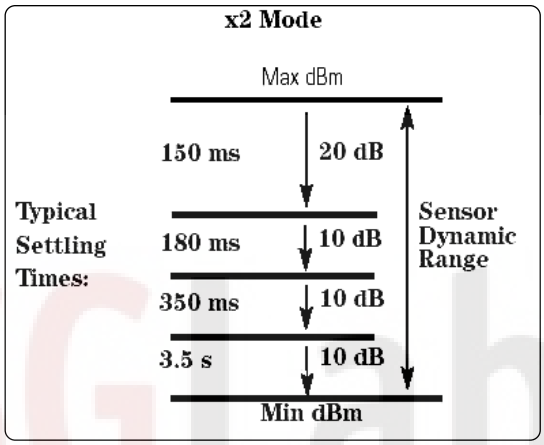
Manual filter, 10 dB decreasing power step.

Table 4

Number of averages	1	2	4	8	16	32	64	128	256	512	1024
Settling time(s) (normal mode)	0.15	0.2	0.3	0.5	1.1	1.9	3.4	6.6	13	27	57
Settling time(s) x2 modes):	0.15	0.18	0.22	0.35	0.55	1.1	1.9	3.5	6.9	14.5	33

Auto filter, default resolution, 10 dB decreasing power step (normal and x2 modes):





For E-series sensors:

In **FAST** mode (using free run trigger), within the range –50 dBm to +17 dBm, for a 10 dB decreasing power step, the settling time is:

E4418B: *10 ms*[2]
E4419B: *20 ms*[2]

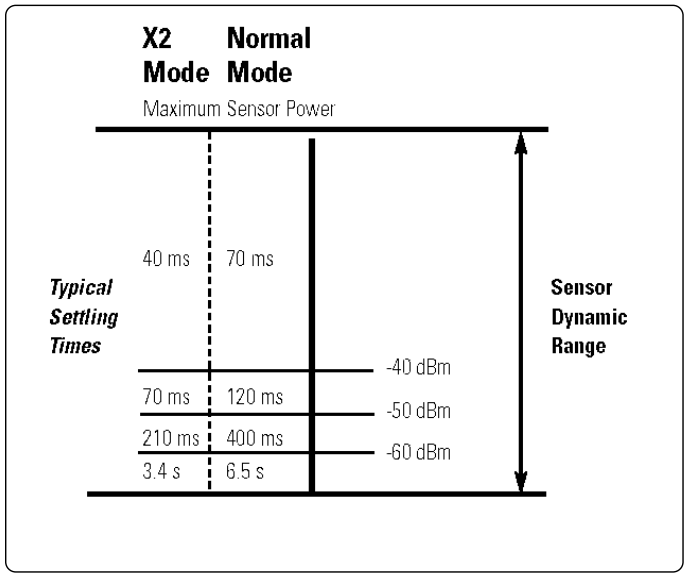
Table 5. Manual filter, 10 dB decreasing power step (not across the range switch point)

Number of averages	1	2	4	8	16	32	64	128	256	512	1024
Settling time(s) (Normal mode)	0.07	0.12	0.21	0.4	1	1.8	3.3	6.5	13	27	57
Settling time(s)	0.04	0.07	0.12	0.21	0.4	1	1.8	3.4	6.8	14.2	32

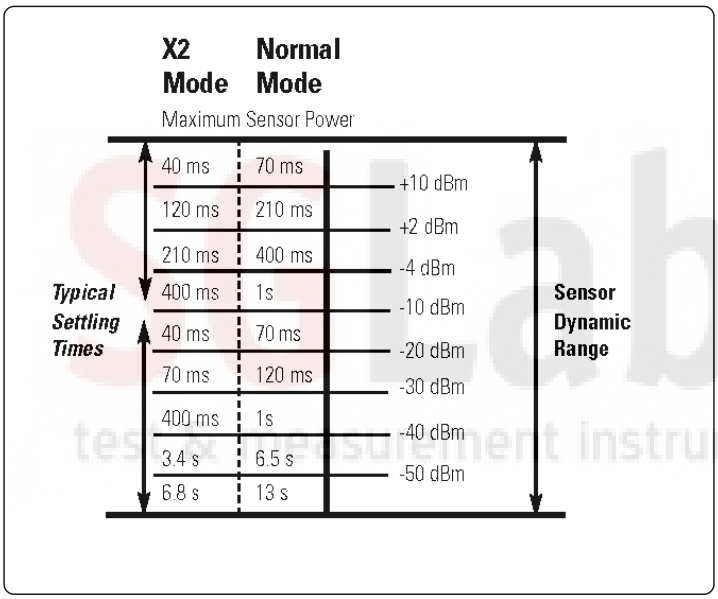
1. Settling time: 0 to 99% settled readings over the GPIB
2. When a power step crosses through the sensor's auto-range switch point, add 25 mS. Refer to the relevant sensor manual for switch point information.

For E4412A and E4413A sensors

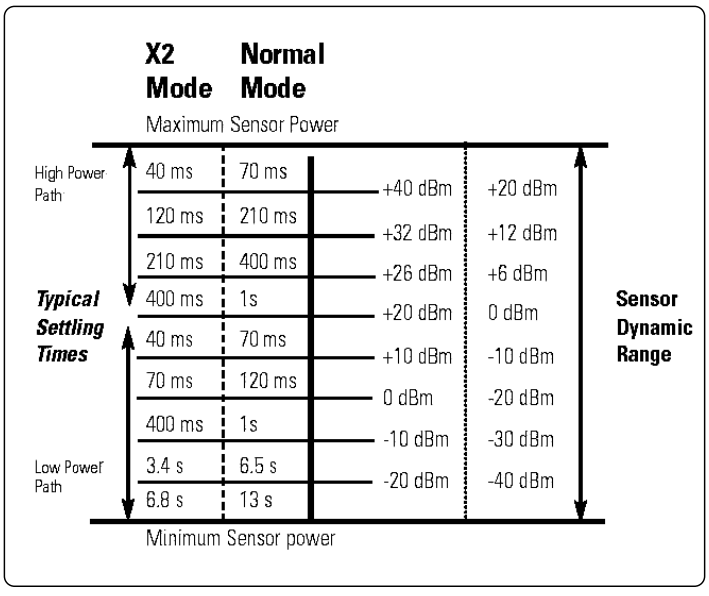
Auto filter, default resolution, 10 dB decreasing power step (not across the range switch point)



For E-series E9300A sensors



For E-series E9300B and H sensors



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Power meter functions

Accessed by key entry: either hardkeys, or softkey menu, and programmable.

Zero: Zeros the meter. (Power reference calibrator is switched off during zeroing.)

Cal: Calibrates the meter using internal (power reference calibrator) or external source. Reference cal factor settable from 1% to 150%, in 0.1% increments.

Frequency: Entered frequency range is used to interpolate the calibration factors table.

Range: 1 kHz to 999.9 GHz, settable in 1 kHz steps.

Cal factor: Sets the calibration Factor for the meter. Range: 1% to 150%, in 0.1% increments.

Relative: Displays all successive measurements relative to the last displayed value.

Offset: Allows power measurements to be offset by –100 dB to +100 dB, settable in 0.001dB increments, to compensate for external loss or gain.

Save/recall: Store up to 10 instrument states via the save/recall menu.

dBm/W: Selectable units of either Watts or dBm in absolute power; or percent or dB for relative measurements.

Filter (averaging): Selectable from 1 to 1024. Auto-averaging provides automatic noise compensation.

Duty cycle: Duty cycle valuesbetween 0.001% to 99.999%, in 0.001% increments, can be entered to display a peak power representation of measured power. The following equation is used to calculate the displayed peak power value: peak power = measured power/dutycycle.

Sensor cal tables: Selects cal factor versus frequency tables corresponding to specified sensors (8480 series only).

Limits: High and low limits can be set in the range –150.000 dBm to +230.000 dBm, in 0.001 dBm increments.

Preset default values: dBm mode, rel off, power reference off, duty cycle off, offset off, frequency 50 MHz, AUTO average, free run, AUTO range (for E-series sensors).

Display: Selectable single and split screen formats are available. A quasi-analog display is available for peaking measurements. The dual channel power meter can simultaneously display any two configurations of A, B, A/B, B/A, A-B, B-A and relative.

General characteristics

Rear panel connectors

Recorder outputs: Analog 0 to 1 Volt, 1 kΩ output impedance, BNC connector. E4419B recorder outputs are dedicated to channel A and channel B.

Remote input/output: A TTL logic level is output when the measurement exceeds a predetermined limit. TTL inputs are provided to initiate zero and calibration cycles. RJ-45 series shielded modular jack assembly connector. TTL Output: high =4.8V max; low = 0.2V max TTL

Input: high = 3.5V min, 5V max; low = 1V max, -0.3V min.

GPIB: Allows communication with an external controller.

RS-232/442: Allows communication with an external RS-232 or RS-422 controller. Male/plug 9 position D-subminiature connector

Ground: Binding post, accepts 4 mm plug or bare-wire connection.

Line power

Input voltage range: 85 to 264 VAC, automatic selection.

Input frequency range: 50 to 440 Hz.

Power requirement: approximately 50 VA (14 Watts) for E4418B and E4419B.

Battery Option 001 operational characteristics[1]

The following information describes characteristic performance based at a temperature of 25°C unless otherwise noted.

Typical operating time: up to 3.5 hours with LED backlight on; up to 5.5 hours with LED backlight off (E4418B power meter).

Charge time: 2 hours to charge fully from an empty state; 50 minutes charging enables 1 hour of operation with LED backlight on; 35 minutes charging enables 1hr operation with LED backlight off. Power meter is operational whilst charging.

Service life: (to 70% of initial capacity at 25°C): 450 charge/discharge cycles

Chemistry: nickel metal hydride

Weight: 1kg

Environmental characteristics

General conditions: Complies with the requirements of the EMC Directive 89/336/EEC. This includes Generic Immunity Standard EN 50082-1: 1992 and Radiated Interference Standard EN 55011: 1991/CISPR11:1990, Group 1 - Class A.

Operating environment

Temperature: 0°C to 55°C.
Maximum humidity: 95% at 40°C (non-condensing).
Minimum humidity: 15% at 40°C (non-condensing).
Maximum altitude: 3000 meters (9840 feet).

Storage conditions

Storage temperature:
–20°C to +70°C.

Non-operating maximum humidity:
90% at 65°C (non-condensing).

Non-operating maximum altitude:
15240 meters (50,000 feet).

General

Dimensions: The following dimensions exclude front and rear protrusions.

212.6 mm W x 88.5 mm H x 348.3 mm D
(8.5 in x 3.5 in x 13.7 in)

Weight

Net: E4418B: 4.0 kg (8.8 lb).
E4419B: 4.1 kg (9.0 lb).

Shipping:
E4418B: 7.9 kg (17.4 lb).
E4419B: 8.0 kg (17.6 lb).

Remote programming

Interface: GBIB interface operates to IEEE 488.2. RS-232 and RS-422 serial interface supplied as standard.

Command language: SCPI standard interface commands. 436A and 437B code compatible (E4418B only); 438A code compatible (E4419B only).

GPIB compatibility: SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP1, DC1, DT1, C0.

Non-volatile memory

Battery: Lithium polycarbon Monoflouride, approximate lifetime 5 years at 25°C.

Safety

Conforms to the following product specifications:
EN61010-1: 1993/IEC 1010-1: 1990 +A1/CSA C22.2 No. 1010-1: 1993
EN60825-1: 1994/IEC 825-1: 1993 Class 1 Low Voltage Directive 72/23/EEC

Accessories supplied

Power sensor cable

11730A: E4418B has one 1.5 meter (5 ft) sensor cable. E4419B has two 1.5 meter (5 ft) sensor cables.
Power cord: One 2.4 meter (7.5 ft) cable. Power plug matches destination requirements.

1. Characteristics describe product performance that is useful in the application of the product, but is not covered by the product warranty.

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EPM series power meters

E4418B: Single channel EPM series power meter

E4419B: Dual channel EPM series power meter

Options available

Power
Option E441xB-001: Mains power and internal rechargeable battery

Connectors
Option E441xB-002: Parallel rear panel sensor input connector(s) and front panel reference calibrator connector
Option E441xB-003: Parallel rear panel sensor input connectors and rear panel reference calibrator connector

Calibration documentation
Option E441xB-A6J: ANSI Z540 compliant calibration test data with measurement uncertainties

Documentation
A hard copy and CD version of the English language User's Guide and Programming Guide is provided with the EPM power meter as standard. A selection can be made to delete the hard copy

Option E441xB-0B0: Delete manual set

Additional documentation
Selections can be made for the localization of the User's Guide, and an English language Service Manual

Option E441xB-915: English language Service Manual
Option E441xB-916: English language manual set (hard copy Users Guide and Programming Guide)
Option E441xB-ABD: German localization (hard copy Users Guide and English Programming Guide)
Option E441xB-ABE: Spanish localization (hard copy Users Guide and English Programming Guide)
Option E441xB-ABF: French localization (hard copy Users Guide and English Programming Guide)
Option E441xB-ABJ: Japanese localization (hard copy Users Guide and English Programming Guide)

Cables
Option E441xB-004: Delete power sensor cable

Additional cables
11730A: Power sensor and SNS noise source cable, length 1.5 meters (5 ft)
11730B: Power sensor and SNS noise source cable, length 3 meters (10 ft)
11730C: Power sensor and SNS noise source cable, length 6.1 meters (20 ft)
11730D: Power sensor cable, length 15.2 meters (50 ft)
11730E: Power sensor cable, length 30.5 meters (100 ft)
11730F: Power sensor cable, length 61 meters (200 ft)

Accessories
Option E441xB-908: Rackmount kit (one instrument)
Option E441xB-909: Rackmount kit (two instruments)
34131A: Transit case for half-rack 2U high instruments
34141A: Yellow soft carry/ operating case
34161A: Accessory pouch
E9287A[1]**:** Spare battery pack for the EPM power meter

Complementary equipment
11683A: Range calibrator

Verifies the accuracy and linearity of the EPM series power meters. Outputs corresponding to meter readings of 3, 10, 30, 100 and 300 µW and 1, 3, 10, 30 and 100 mW are provided. Calibration uncertainty is ±0.25% on all ranges.

Service options
Warranty
Included with each EPM series power meter[2] is a standard 12 month return to Agilent warranty and service plan. For warranty and service of 5 years, please order 60 months of R-51B.

R-51B: Return-to-Agilent warranty and service plan

Calibration[3]
For 3 years, order 36 months of the appropriate calibration plan shown below. For 5 years, specify 60 months.
R-50C-001: Standard calibration plan
R-50C-002: Standard compliant calibration plan

The E-series and 8480 series power sensors have a 12 months return to Agilent warranty and service plan. For more information, contact your local sales and service office.

1. Only for EPM series power meter with Option E441XB-001 installed.
2. For Option E441XB-001, the 36 month warranty does not apply to the E9287A battery pack.
3. Options not available in all countries.

E-series power sensor specifications

The E-series of power sensors have their calibration factors stored in EEPROM and operate over a wide dynamic range. They are designed for use with the EPM series of power meters and two classes of sensors are available:

- CW power sensors (E4412A and E4413A).
- Average power sensors (E9300 sensors).

E-series CW power sensor specifications

Wide dynamic range CW sensors: 100 pW to 100 mW (-70 dBm to +20 dBm)

Table 6

Model	Frequency range	Maximum SWR	Maximum power	Connector type
E4412A	10 MHz – 18 GHz	*10 MHz to 30 MHz: 1.12 30 MHz to 2 Ghz:1.15 2 GHz to 6 Ghz:1.17 6 GHz to 11 Ghz:1.2 11 GHz to 18 Ghz:1.27	200 mW (+23 dBm)	Type-N (m)
E4413A	50 MHz – 26.5 GHz	50 MHz to 100 MHz: 1.21 100 MHz to 8 Ghz:1.19 8 GHz to 18 Ghz:1.21 18 GHz to 26.5 Ghz:1.26	200 mW (+23 dBm)	APC-3.5mm (m)

* Applies to sensors with serial prefix US 3848 or greater

Power linearity

Table 7

Power	Temperature (25°C ±5°C)	Temperature (0° to 55°C)
100 pW to 10 mW (-70 dBm to +10 dBm)	±3 %	±7 %
10 mW to 100 mW (+10 dBm to +20 dBm)	±4.5%	±10%

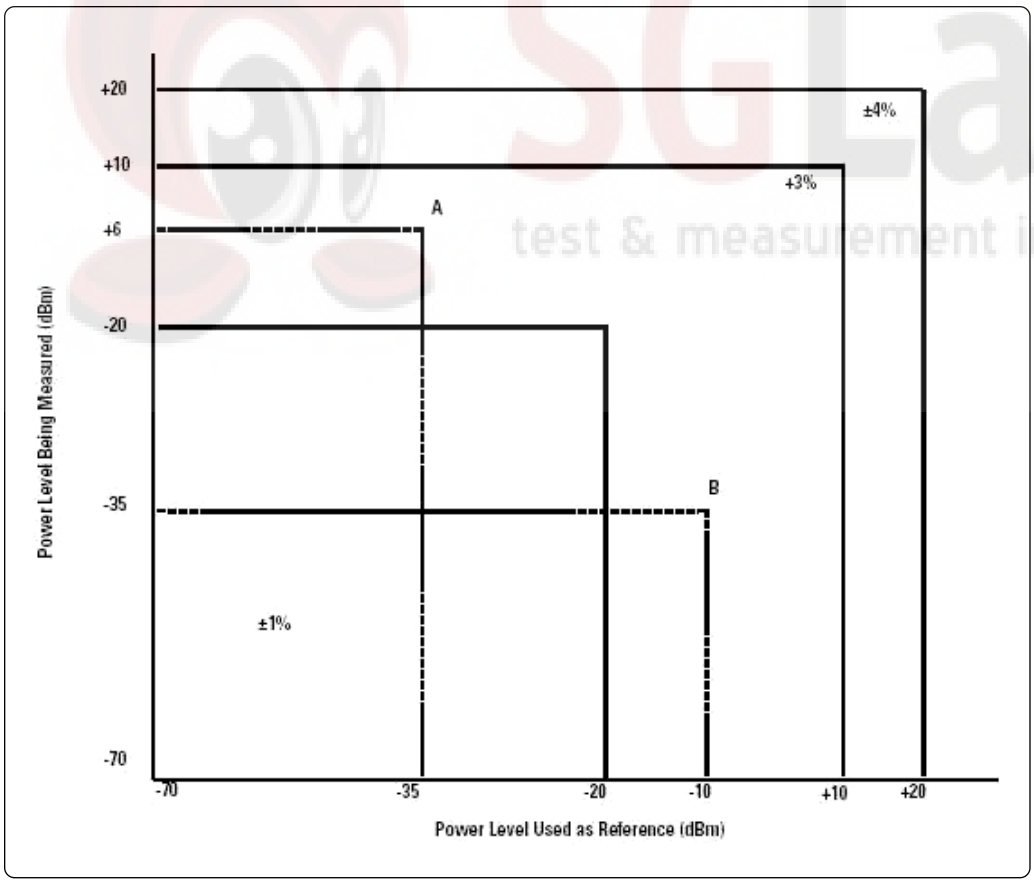

Figure 1 : Relative mode power measurement linearity with EPM series power meter/E-series CW power sensor at 25°C ± 5°C (typical)

The chart in figure 1 shows the typical uncertainty in making a relative power measurement, using the same power meter channel and the same power sensor to obtain the reference and the measured values. Example A illustrates a relative gain (amplifier measurement). Example B illustrates a relative loss (insertion loss measurement). This chart assumes negligible change in frequency and mismatch occur when transitioning from the power level used as the reference to the power level being measured.

Example A:
P = 10(P)/10 x 1 mW
P = 10 6/10 x 1 mW
P = 3.98 mW
3% x 3.98 mW = 119.4 µW
(where P = power in Watts, and (P) = power in dBm)

Example B:
P = 10 (P)/10 x1 mW
P = 10 -35/10 x 1 mW
P = 316 nW
3% x 316 nW = 9.48 nW

General

Dimensions:
E4412A:
130 mm L x 38 mm W x 30 mm H
(5.1 in x 1.5 in x 1.2 in)
E4413A:
102 mm L x 38 mm W x 30 mm H
(4 in x 1.5 in x 1.2 in)

Weight:
E4412A: 0.18 kg (0.4 lb).
E4413A: 0.18 kg (0.4 lb).

Calibration factor (CF) and reflection coefficient (Rho)

Calibration factor and reflection coefficient data are provided at 1 GHz increments on a data sheet included with the power sensor. This data is unique to each sensor. If you have more than one sensor,match the serial number on the data sheet with the serial number on the power sensor you are using. The CF corrects for the frequency response of the sensor. The EPM power meter automatically reads the CF data stored in the sensor and uses it to make the corrections. For power levels greater than 0 dBm, add 0.5%/dB to the calibration factor uncertainty specification.

Reflection coefficient (Rho) relates to the SWR according to the following formula: SWR = 1 + Rho/1 - Rho

Maximum uncertainties of the CF data are listed in table 8a, for the E4412A power sensor, and table 8b for the E4413A power sensor. The uncertainty analysis for the calibration of the sensors was done in accordance with the ISO/TAG4 Guide. The uncertainty data reported on the calibration certificate is the expanded uncertainty with a 95% confidence level and a coverage factor of 2.

Table 8a. E4412A calibration factor uncertainty at 1 mW (0 dBm)

Frequency	Uncertainty (%)
10 MHz	1.8
30 MHz	1.8
50 MHz	Reference
100 MHz	1.8
1.0 GHz	1.8
2.0 GHz	2.4
4.0 GHz	2.4
6.0 GHz	2.4
8.0 GHz	2.4
10.0 GHz	2.4
11.0 GHz	2.4
12.0 GHz	2.4
14.0 GHz	2.4
16.0 GHz	2.6
18.0 GHz	2.6

Table 8b. E4413A calibration factor uncertainty at 1 mW (0 dBm)

Frequency	Uncertainty (%)
50 MHz	Reference
100 MHz	1.8
1.0 GHz	1.8
2.0 GHz	2.4
4.0 GHz	2.4
6.0 GHz	2.4
8.0 GHz	2.4
10.0 GHz	2.6
11.0 GHz	2.6
12.0 GHz	2.8
14.0 GHz	2.8
16.0 GHz	2.8
17.0 GHz	2.8
18.0 GHz	2.8
20.0 GHz	3
22.0 GHz	3
24.0 GHz	3
26.0 GHz	3
28.0 GHz	3

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E-series E9300 average power sensor specifications

The E-series E9300 wide dynamic range, average power sensors are designed for use with the EPM family of power meters. These specifications are valid ONLY after proper calibration of the power meter and apply for CW signals unless otherwise stated.

Specifications apply over the temperature range 0°C to 55°C unless otherwise stated, and specifications quoted over the temperature range 25°C ±10°C, conform to the standard environmental test conditions as defined in TIA/EIA/ IS-97-A and TIA/EIA/IS-98-A [1].

The E-series E9300 power sensors have two independent measurement paths (high and low power paths):

High power path: -10 to +20 dBm ("A" suffix sensors), +20 to +44 dBm ("B" suffix sensors) and 0 to +30 dBm ("H" suffix sensors).

Low power path: -60 to -10 dBm ("A" suffix sensors), -30 to +20 dBm ("B" suffix sensors) and -50 to 0 dBm ("H" suffix sensors).

Some specifications are detailed for an individual measurement path.

Table 9
Wide dynamic range (-60 to +20 dBm) sensors

Model	Frequency range	Maximum SWR (25°C ± 10°C)	Maximum SWR (0 – 55°C)	Maximum power	Connector type
E9300B	10 MHz – 18.0 GHz	10 MHz to 30 GHz: 1.15 30 MHz to 2 GHz: 1.13 2 GHz to 14 GHz: 1.19 14 GHz to 16 GHz: 1.22 16 GHz to 18 GHz: 1.26	10 MHz to 30 MHz: 1.21 30 MHz to 2 GHz: 1.15 2 GHz to 14 GHz: 1.20 14 GHz to 16 GHz: 1.23 16 GHz to 18 GHz: 1.27	+25 dBm average; +33 dBm peak (< 10 µsec)	Type-N (m)
E9301A	10 MHz – 6.0 GHz	10 MHz to 30 GHz: 1.15 30 MHz to 2 GHz: 1.13 2 GHz to 14 GHz: 1.19	10 MHz to 30 MHz: 1.21 30 MHz to 2 GHz: 1.15 2 GHz to 14 GHz: 1.20	+25 dBm average; +33 dBm peak (< 10 µsec)	Type-N (m)
E9304A	9 MHz – 6.0 GHz	9 kHz to 2 GHz: 1.13 2 GHz to 6 GHz: 1.19	9 kHz to 2 GHz: 1.15 2 GHz to 6 GHz: 1.20	+25 dBm average; +33 dBm peak (< 10 µsec)	Type-N (m)

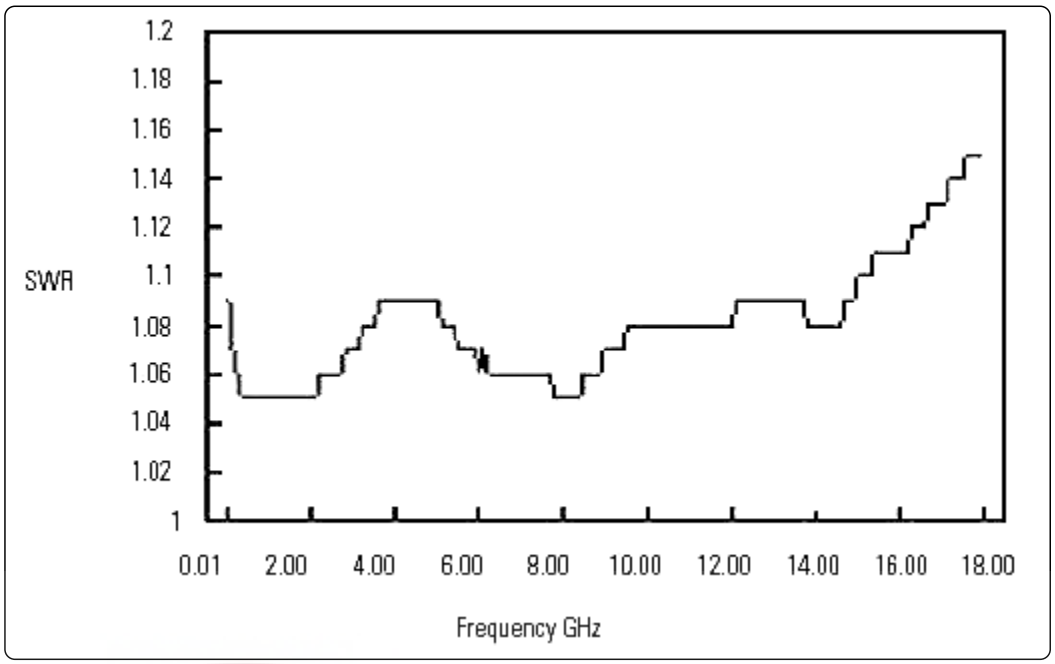
Wide dynamic range (-30 to +44 dBm) sensors

Model	Frequency range	Maximum SWR (25°C ± 10°C)	Maximum SWR (0 – 55°C)	Maximum power	Connector type
E9300B	10 MHz – 18.0 GHz	10 MHz to 8 GHz: 1.12 8 to 12.4 GHz: 1.17 12.4 to 18 GHz: 1.24	10 MHz to 8 GHz: 1.14 8 to 12.4 GHz: 1.18 12.4 to 18 GHz: 1.25	0 – 35°C: 30 W avg 35 – 55°C: 25 W avg < 6 GHz: 500 W pk > 6 GHz: 125 W pk 500 W-mS per pulse	Type-N (m)
E9301B	10 MHz – 6.0 GHz	10 MHz to 6 GHz: 1.12	10 MHz to 6 GHz: 1.14	0 – 35°C: 30 W avg 35 – 55°C: 25 W avg < 6 GHz: 500 W pk 500 W-mS per pulse	Type-N (m)

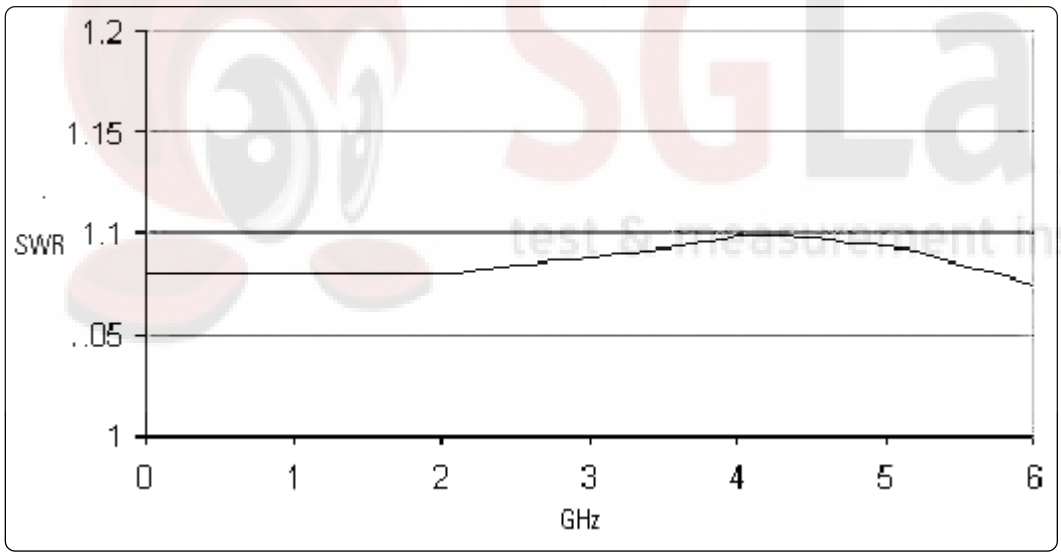
Wide dynamic range (-50 to +30 dBm) sensors

Model	Frequency range	Maximum SWR (25°C ± 10°C)	Maximum SWR (0 – 55°C)	Maximum power	Connector type
E9300H	10 MHz – 18.0 GHz	10 MHz to 8 GHz: 1.15 8 to 12.4 GHz: 1.25 12.4 to 18 GHz: 1.28	10 MHz to 8 GHz: 1.17 8 to 12.4 GHz: 1.26 12.4 to 18 GHz: 1.29	3.16 W avg 100 W pk 100 W-µS per pulse	Type-N (m)
E9301H	10 MHz – 6.0 GHz	10 MHz to 6 GHz: 1.15	10 MHz to 6 GHz: 1.17	3.16 W avg 100 W pk 100 W-µS per pulse	Type-N (m)

Typical SWR, 10 MHz to 18 GHz, (25°C ± 10°C) for E9300A and E9301A sensors



Typical SWR, 9kHz to 6 GHz, (25°C ± 10°C) for E9304A sensors



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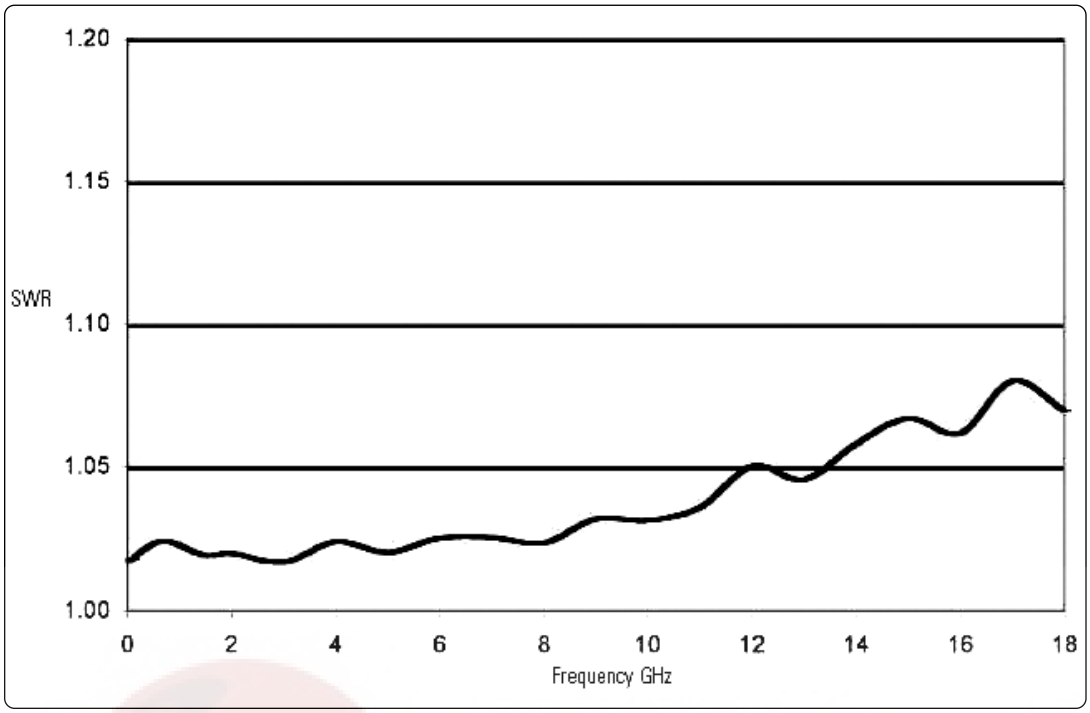
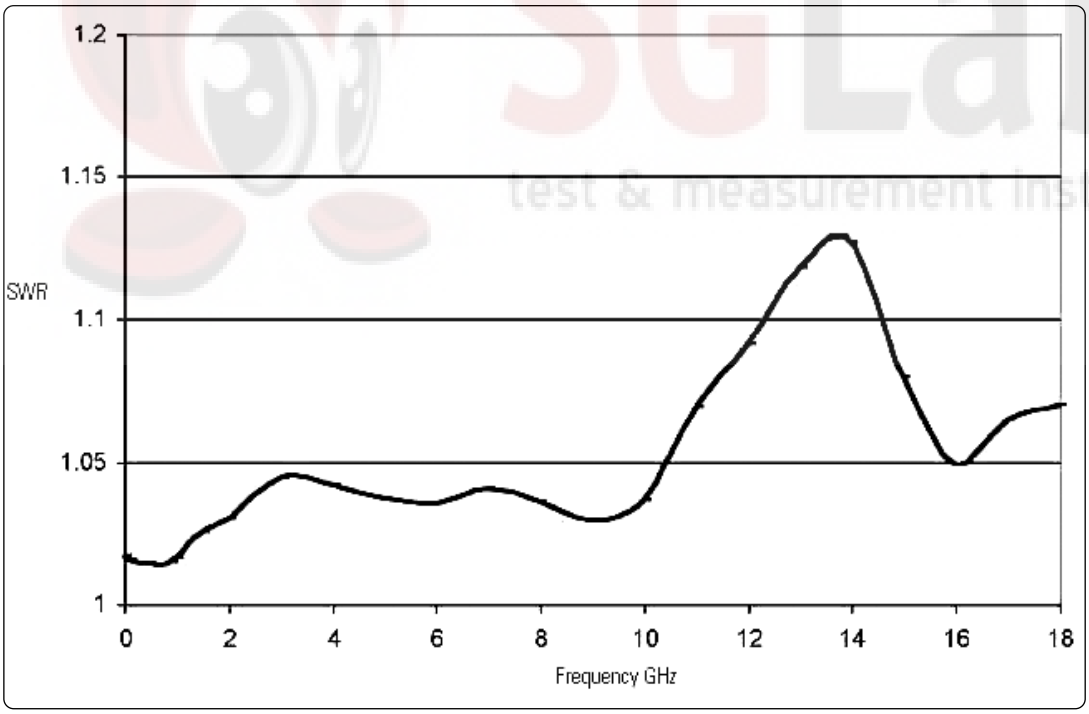
Typical SWR, 10 MHz to 18 GHz, (25°C ± 10°C) for E9300B and E9301B sensors



Typical SWR, 10 MHz to 18 GHz, (25°C ± 10°C) for E9300H and E9301H sensors



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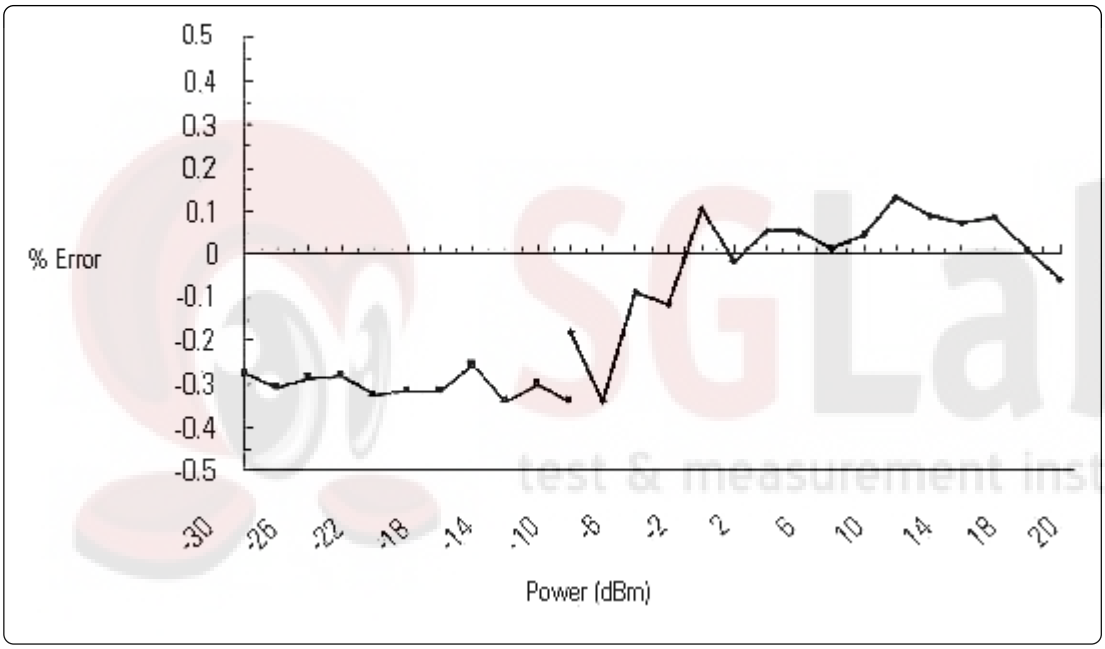
E-series E9300 average power sensors

Table 10. Power linearity (after zero and cal at ambient environmental conditions)

Sensor	Power	Linearity (25°C ± 10°C)	Linearity (0 – 55°C)
E9300A, E9301A, E9304A	-60 to –10 dBm	±3.0%	±3.5%
	-10 to 0 dBm	±2.5%	±3.0%
	0 to +20 dBm	±2.0%	±2.5%
E9300B, E9301B	-30 to +20 dBm	±3.5%	±4.0%
	+20 to +30 dBm	±3.0%	±3.5%
	+30 to +44 dBm	±2.5%	±3.0%
E9300H, E9301H	-50 to 0 dBm	±4.0%	±5.0%
	0 to +10 dBm	±3.5%	±4.0%
	+10 to +30 dBm	±3.0%	±3.5%

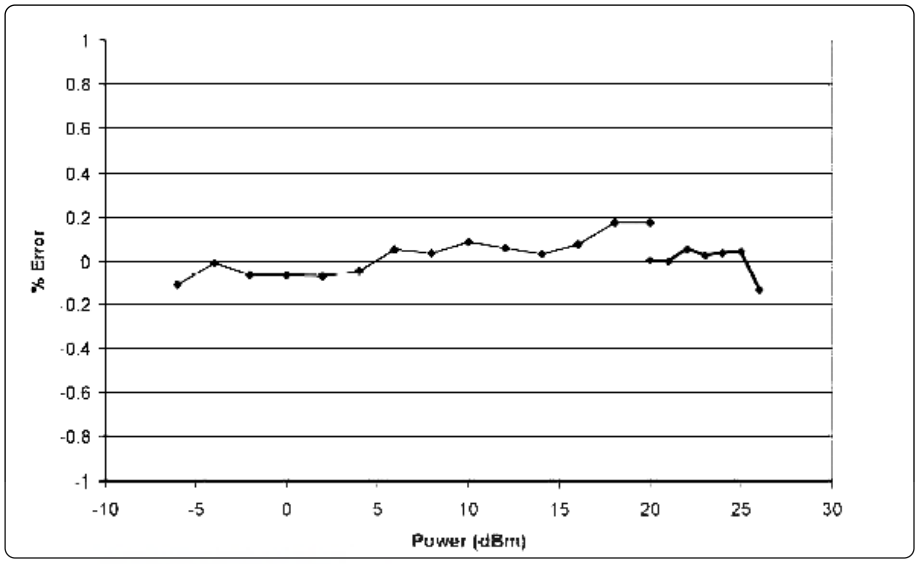
Typical E9300A/01A/04A Power Linearity at 25°C, after zero and calibration, with associated measurement uncertainty



Power range	-30 to -20 dBm	-20 to -10 dBm	-10 to 0 dBm	0 to +10 dBm	+10 to +20 dBm
Measurement uncertainty	±0.9%	±0.8%	±0.65%	±0.55%	±0.45%

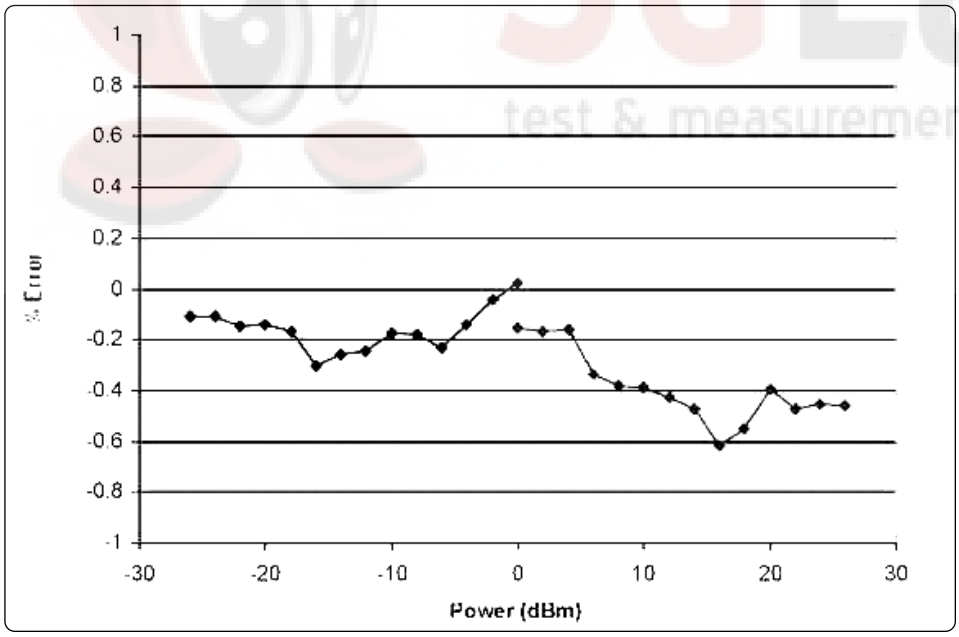
E-series E9300 average power sensors

Typical E9300B/01B power linearity at 25°C, after zero and calibration, with associated measurement uncertainty



Power range	-6 to 0 dBm	0 to +10 dBm	+10 to +20 dBm	+20 to +26 dBm
Measurement uncertainty	± 0.65%	± 0.55%	± 0.45%	± 0.31%

Typical E9300H/01H power linearity at 25°C, after zero and calibration, with associated measurement uncertainty



Power range	-26 to -20 dBm	-20 to –10 dBm	-10 to 0 dBm	0 to +10 dBm	+10 to +20 dBm	+20 to +26 dBm
Measurement uncertainty	± 0.9%	± 0.8%	± 0.65%	± 0.55%	± 0.45%	± 0.31%

Note: If the temperature changes after calibration and you choose not to re-calibrate the sensor, the following additional power linearity error should be added to the linearity specs in table 10: the typical maximum additional power linearity error due to temperature change after calibration, for small changes in temperature, is ±0.15%/°C (valid after zeroing the sensor).

For large changes in temperature, refer to Table 11.

Typical maximum additional power linearity error due to temperature change after calibration at 25°C for any change in temperature (valid after zeroing the sensor)

Table 11

Sensor	Power	Additional power linearity error (25°C ± 10°C)	Additional power linearity error (0 – 55°C)
E9300A, E9301A, E9304A	-60 to –10 dBm	±1.5%	±2.0%
	-10 to 0 dBm	±1.5%	±2.5%
	0 to +20 dBm	±1.5%	±2.0%
E9300B, E9301B	-30 to +20 dBm	±1.5%	±2.0%
	+20 to +30 dBm	±1.5%	±2.5%
	+30 to +44 dBm	±1.5%	±2.0%
E9300H, E9301H	-50 to 0 dBm	±1.5%	±2.0%
	0 to +10 dBm	±1.5%	±2.5%
	+10 to 30 dBm	±1.5%	±2.0%

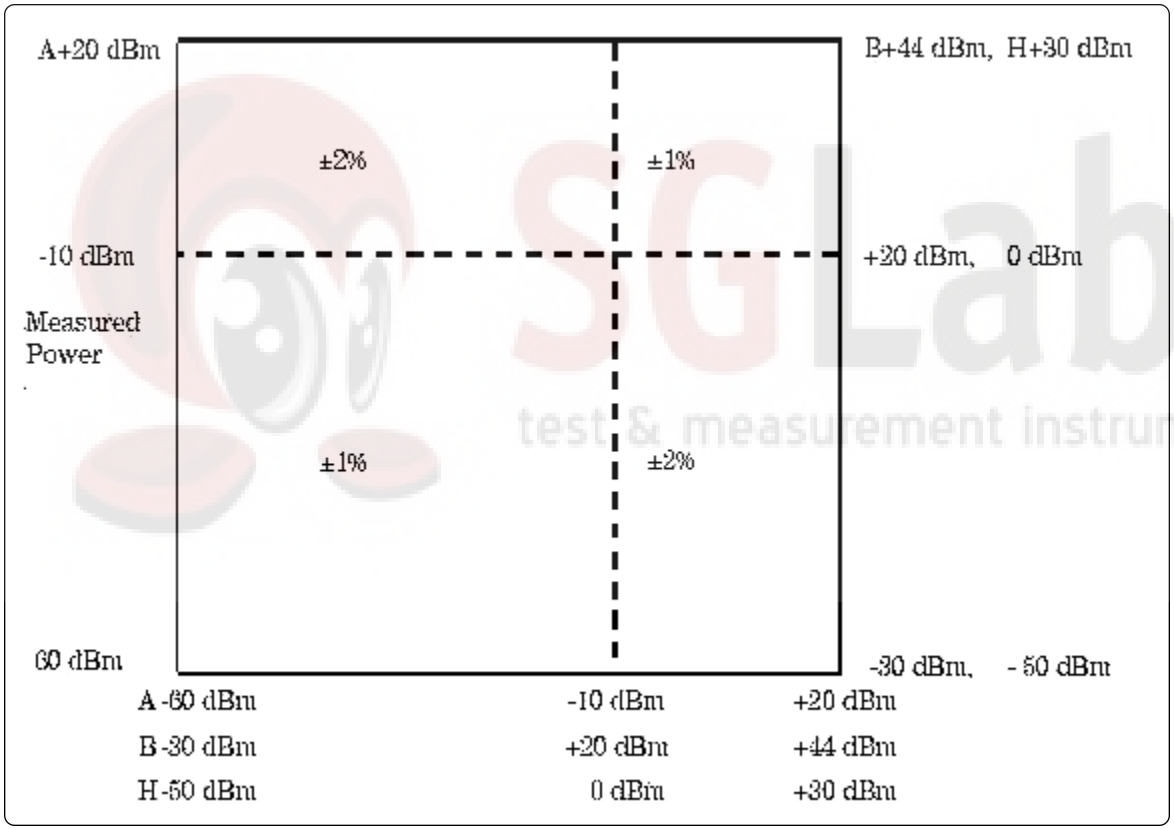


Figure 2. Relative mode power measurement linearity with an EPM series power meter, at 25°C ±10°C (typical)

Figure 2 shows the typical uncertainty in making a relative power measurement, using the same power meter channel and same power sensor to obtain the reference and the measured values, and assumes that negligible change in frequency and mismatch error occur when transitioning from the power level used as the reference to the power level being measured.

E-series E9300 average power sensors

Switch point data

The E9300 power sensors have two paths, a low power path covers: -60 to -10 dBm ("A" suffix sensors), -30 to +20 dBm ("B" suffix sensors), and -50 to 0 dBm ("H" suffix sensors). The high power path covers: -10 to +20 dBm ("A" suffix sensors), +20 to +44 dBm ("B" suffix sensors), and 0 to +30 dBm ("H" suffix sensors). The power meter automatically selects the proper power level path. To avoid unnecessary switching when the power level is near the switch point, switching point hysteresis has been added.

E9300 "A" suffix sensors example: hysteresis causes the low power path to remain selected until approximately -9.5 dBm as the power level is increased, above this power the high power path will be selected. The high power path will remain selected until approximately -10.5 dBm is reached as the signal level decreases, below this power the low power path will be selected.

Switching point linearity: *Typically ≤ ±0.5% (≤ ±0.02 dB)*
Switching point hysteresis: *0.5 dB typical*

Table 12. E9300A, E9301A, and E9304A sensors zero and measurement noise

Conditions[1]	Zero set	Zero drift[2]	Measurement noise[3]
Low power path (15% to 75% RH)	500 pW	150 pW	700 pW
Low power path (75% to 95% RH)	500 pW	4,000 pW	700 pW
High power path (15% to 75% RH)	500 nW	150 nW	500 nW
High power path (75% to 95% RH)	500 nW	3 nW	500 nW

E9300B and E9301B sensors

Conditions[1]	Zero set	Zero drift[2]	Measurement noise[3]
Low power path (15% to 75% RH)	500 nW	150 nW	700 nW
Low power path (75% to 95% RH)	500 nW	4 µW	700 nW
High power path (15% to 75% RH)	500 µW	150 µW	500 µW
High power path (75% to 95% RH)	500 µW	3 mW	500 µW

E9300H and E9301H sensors

Conditions[1]	Zero set	Zero drift[2]	Measurement noise[3]
Low power path (15% to 75% RH)	5 nW	1.5 nW	7 nW
Low power path (75% to 95% RH)	5 nW	40 nW	7 nW
High power path (15% to 75% RH)	5 µW	1.5 µW	5 µW
High power path (75% to 95% RH)	5 µW	30 µW	5 µW

1. RH is the abbreviation for relative humidity.
2. Within 1 hour after zero set, at a constant temperature, after a 24-hour warm-up of the power meter with power sensor connected.
3. The number of averages at 16 for normal mode and 32 for x2 mode, at a constant temperature, measured over a one minute interval and two standard deviations.

Calibration factor (CF) and reflection coefficient (Rho)

Calibration factor and reflection coefficient data are provided at frequency intervals on a data sheet included with the power sensor. This data is unique to each sensor. If you have more than one sensor, match the serial number on the data sheet with the serial number on the power sensor you are using. The CF corrects for the frequency response of the sensor. The EPM series power meter automatically reads the CF data stored in the sensor and uses it to make the corrections.

Reflection coefficient (Rho) relates to the SWR according to the following formula:
SWR = (1 + Rho)/(1 - Rho)

Maximum uncertainties of the CF data are listed in tables 13A and 13B. As the E-series E9300 power sensors have two independent measurement paths (high and low power paths), there are two calibration factor uncertainty tables. The uncertainty analysis for the calibration of the sensors was done in accordance with the ISO Guide. The uncertainty data reported on the calibration certificate is the expanded uncertainty with a 95% confidence level and a coverage factor of 2.

Table 13A. Calibration factor uncertainties (low power path)

Frequency	Uncertainty (%) (25°C +10°C)	Uncertainty (%) (0° to 55°C)
10 MHz to 30 MHz	± 1.8%	±2.2%
30 MHz to 500 MHz (E9304A: 9kHz to 500MHz)	±1.6%	±2.0%
500 MHz to 1.2 GHz	±1.8%	±2.5%
1.2 GHz to 6 GHz	±1.7%	±2.0%
6 GHz to 14 GHz	±1.8%	
14 GHz to 18 GHz ± 2.0 %	±2.0%	±2.2%

Table 13B Calibration factor uncertainties (high power path)

Frequency	Uncertainty (%) (25°C +10°C)	Uncertainty (%) (0° to 55°C)
10 MHz to 30 MHz	±2.1%	±4.0%
30 MHz to 500 MHz (E9304A: 9kHz to 500MHz)	±1.8%	±3.0%
500 MHz to 1.2 GHz	±2.3%	±4.0%
1.2 GHz to 6 GHz	±1.8%	±2.1%
6 GHz to 14 GHz	±1.9%	±2.3%
14 GHz to 18 GHz	±2.2%	±3.3%

General

Dimensions: Length 130 mm, width 38 mm, height 30 mm

Weight: 0.18 kg (0.4 lbs)

References:

[1] TIA is the Telecommunications Industry Association; EIA is the Electronic Industries Association. TIA/EIA/IS-97-A is the recommended minimum performance standards for base stations supporting dual-mode wideband spread spectrum cellular mobile stations. TIA/EIA/IS-98-A is the recommended minimum performance standards for dual-mode wideband spread spectrum cellular mobile stations.

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8480 series power sensors (with EPM series power meters)

The 8480 series power sensors are designed for use with the 435B, 436A, 437B, 438A, 70100A, E1416A and now the E4418B and E4419B power meters. These thermocouple and diode power sensors provide extraordinary accuracy, stability, and SWR over a wide range of frequencies (100 kHz to 110 GHz) and power levels -70 dBm to +44 dBm).

Table 14. Root sum of squares (rss) uncertainty on the calibration factor data printed on the power sensor

Freq (MHz)	8482A	8482B	8482H	8483A
0.1	1.3	2.8	1.6	1.5
0.3	1.2	2.8	1.6	1.4
1	1.2	2.8	1.6	1.4
3	1.2	2.8	1.6	1.4
10	1.3	2.8	1.6	1.6
30	1.4	2.8	1.7	1.6
50	0 (ref)	2.7	0 (ref)	0 (ref)
100	1.6	3.3	1.9	2
300	1.6	3.3	1.9	2
1000	1.4	3.3	1.7	2
2000	1.4	3.3	1.7	2.1
4000	1.5	3.1	1.8	-

Freq (GHz)	8481A	8481B	8481H	8481D	8485A	8385D	8487A	8487D
1	1.6	3	1.9	1.9	1.6	1.8	1.6	2
2	1.4	3.1	1.7	1.8	1.6	1.8	1.6	2
4	1.5	3.1	1.8	1.8	1.7	1.8	1.6	2
6	1.5	3.1	1.8	1.8	1.8	2.1	1.7	2.3
8	1.7	3.2	2	2	1.9	2.2	1.8	2.3
10	1.9	3.3	2.2	2.2	2	2.1	1.8	2.3
12	2.1	4.1	2.4	2.8	2	2.2	1.9	2.3
14	2.6	4.1	2.8	3.2	2.2	2.2	2.1	2.8
16	2.9	4.2	3	3.4	2.3	2.5	2.2	2.8
18	3.2	4.3	3.1	3.7	2	2.6	2.3	2.8
22	-	-	-	-	2.1	2	1.8	2.8
26.5	-	-	-	-	2.1	2.3	2.1	2.8

Freq (GHz)	R8486A	Q8486A	R8486D	Q8486D	8487A	8487D
26.5	2.2	-	3	-	2.1	2.8
28	2.4	-	3.2	-	2.3	3
30	2.5	-	3	-	2.1	3
33	2.1	2.8	3	4.2	2.3	3
34.5	2.1	2.8	3	4.2	2.1	3
37	2.2	2.8	3	4.2	2.3	3
40	2.2	2.9	3	4.2	2.6	3
42	-	3.9	-	4.9	3.2	2.9
44	-	3.9	-	5.1	3.6	2.9
46	-	3.9	-	5.5	4.1	3.1
48	-	4.9	-	5.8	4.5	4.5
50	-	5.3	-	6.2	5	4.5

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8480 series sensors (with EPM series power meters)

Table 15

25 Watt sensors, 1 mW to 25 W (0 dBm to +44 dBm)

Model	Frequency range	Maximum SWR	Power linearity[1]	Maximum power	Connector type	Weight
8481B	10 MHz to 18 GHz	10 MHz to 2 GHz: 1.10 2 GHz to 12.4 GHz: 1.18 12.4 GHz to 18 GHz: 1.28	+35 dBm to + 44 dBm: (±4%)	0°C to 350°C: 30W avg [2] 35°C to 550°C: 25W avg 0.01 to 5.8 GHz: 500W pk 5.8 to 18 GHz: 125 W pk 500 W.µs per pulse	Type - N(m)	Net: 0.8 kg (1.75 lb) Shipping: 1.5 kg (3.25 lb)
8482B	100 kHz to 4.2 GHz	100 kHz to 2 GHz: 1.10 2 GHz to 4.2 GHz: 1.18	+35 dBm to + 44 dBm: (±4%)	0°C to 350°C: 30W avg [2] 35°C to 550°C: 25W avg 0.01 to 5.8 GHz: 500W pk 5.8 to 18 GHz: 125 W pk 500 W - µs per pulse	Type - N(m)	Net: 0.8 kg (1.75 lb) Shipping: 1.5 kg (3.25 lb)

3 Watt sensors, 100 µW to 3 W (–10 dBm to +35 dBm)

Model	Frequency range	Maximum SWR	Power linearity (1)	Maximum power	Connector type	Weight
8481H	10 MHz to 18 GHz	10 MHz to 8 GHz: 1.20 8 GHz to12.4 GHz: 1.25 12.4 GHz to 18 GHz: 1.30	+25 dBm to + 35 dBm: (±5%)	3.5 W avg, 100 W pk 100 W.µs per pulse	Type - N (m)	Net: 0.2 kg (0.38 lb) Shipping: 0.5 kg (1.0 lb)
8482H	100 kHz to 4.2 GHz	100 kHz to 4.2 GHz: 1.20	+25 dBm to + 35 dBm: (±5%)	3.5 W avg, 100 W pk 100 W.µs per pulse	Type - N (m)	Net: 0.2 kg (0.38 lb) Shipping: 0.5 kg (1.0 lb)

100 mW sensors, 1 µW to 100 mW (–30 dBm to +20 dBm)

Model	Frequency range	Maximum SWR	Power linearity (1)	Maximum power	Connector type	Weight
8485A	50 MHz to 26.5 GHz	50 MHz to 100 MHz: 1.15 100 MHz to 2 GHz: 1.10 2 GHz to 12.4 GHz: 1.15 12.4 GHz to 18 GHz: 1.20 18 GHz to 26.5 GHz: 1.25	+10 dBm to + 20 dBm: (±3%)	300 mW avg, 15 W pk 30 W.µs per pulse	APC - 3.5mm(m)	Net: 0.2 kg (.38 lb) Shipping: 0.5 kg (1.0 lb)
Option 8485A-033	50 MHz to 33 GHz	26.5 GHz to 33 GHz: 1.40	+10 dBm to + 20 dBm: (±3%)	300 mW avg, 15 W pk 30 W.µs per pulse	APC - 3.5mm(m)	Net: 0.2 kg (.38 lb) Shipping: 0.5 kg (1.0 lb)
8481A	10 MHz to 18 GHz	10 MHz to 30 MHz: 1.40 30 MHz to 50 MHz: 1.18 50 MHz to 2 GHz: 1.10 2 GHz to 12.4 GHz: 1.18 12.4 GHz to 18 GHz: 1.28	+10 dBm to + 20 dBm: (±3%)	300 mW avg, 15 W pk 30 W.µs per pulse	Type - N (m)	Net: 0.2 kg (0.38 lb) Shipping: 0.5 kg (1.0 lb)
8482A	100 kHz to 4.2 GHz	100 kHz to 300 kHz: 1.60 300 kHz to 1 MHz: 1.20 1 MHz to 2 GHz: 1.10 2 GHz to 4.2 GHz: 1.30	+10 dBm to + 20 dBm: (±3%) 30 W.µs per pulse	300 mW avg, 15 W pk	Type - N (m)	Net: 0.2 kg (0.38 lb) Shipping: 0.5 kg (1.0 lb)
8483A (75 ohm)	100 kHz to 2 GHz	100 kHz to 600 kHz: 1.80 600 kHz to 2 GHz: 1.18	+10 dBm to + 20 dBm: (±3%)	300 mW avg, 10 W pk	Type - N (m) (75 ohm)	Net: 0.2 kg (0.38 lb) Shipping: 0.5 kg (1.0 lb)
R8486A	26.5 GHz to 40 GHz	26.5 GHz to 40 GHz: 1.40	+10 dBm to + 20 dBm: (±3%)	300 mW avg, 15 W pk 30 W.µs per pulse	Waveguide flange UG-599/U	Net: 0.26 kg (0.53 lb) Shipping: .66 kg (1.3 lb)
Q8486A	33 GHz to 50 GHz	33 GHz to 50 GHz: 1.50	+10 dBm to + 20 dBm: (±3%)	300 mW avg, 15 W pk 30 W.µs per pulse	Waveguide flange UG-383/U	Net: 0.26 kg (0.53 lb) Shipping: .66 kg (1.3 lb)
V8486A	50 GHz to 75 GHz	50 GHz to 75 GHz: 1.06	+10 dBm to + 20 dBm: (±2%) -30 dBm to + 10 dBm: (±1%)	200 mW avg, 40 W pk (10.µs per pulse, 0.5% duty cycle)	Waveguide flange UG-385/U	Net: 0.4 kg (0.9 lb) Shipping: 1 kg (2.1 lb)
W8486A	75 GHz to 110 GHz	75 GHz to 110 GHz: 1.08	(±2%)	200 mW avg, 40 W pk (10.µs per pulse, 0.5% duty cycle)	Waveguide flange UG-387/U	Net: 0.4 kg (0.9 lb) Shipping: 1 kg (2.1 lb)
8487A	50 MHz to 50 GHz	50 MHz to 100 MHz: 1.15 100 MHz to 2 GHz: 1.10 2 GHz to 12.4 GHz: 1.15 12.4 GHz to 18 GHz: 1.20 18 GHz to 26.5 GHz: 1.25 26.5 GHz to 40 GHz: 1.30 40 GHz to 50 GHz: 1.50	+10 dBm to + 20 dBm: (±3%)	300 mW avg, 15 W pk 30 W.µs per pulse	2.4 mm (m)	Net: 0.14 kg (.28 lb) Shipping: 0.5 kg (1.0 lb)

1. Negligible deviation except for those power ranges noted.
2. For pulses greater than 30 W, the maximum average power (P_a) is limited by the energy per pulse (E) in W.µs according to $P_a = 30\text{-}0.02\ E$.

8480 series sensors (with EPM series power meters)

High sensitivity sensors, 100 pW to 10 µW (–70 dBm to –20 dBm)

Model	Frequency range	Maximum SWR	Power linearity[1]	Maximum power	Connector type	Weight
8481D[3]	10 MHz to 18 GHz	10 MHz to 30 MHz: 1.40 30 MHz to 3 GHz: 1.15 4 GHz to 10 GHz: 1.20 10 GHz to 15 GHz: 1.30 15 GHz to 18 GHz: 1.50	- 30 dBm to - 20 dBm: (±1%)	100 mW avg, 100 m W pk	Type - N (m)	Net: 0.16 kg (0.37 lb) Shipping: 0.9 kg (2.0 lb)
8485D[3]	50 MHz to 26.5 GHz	0.05 GHz to 0.1 GHz: 1.19 0.1 GHz to 4 GHz: 1.15 4 GHz to 12 GHz: 1.19 12 GHz to 18 GHz: 1.25 18 GHz to 26.5 GHz: 1.29	-30 dBm to -20 dBm: (±2%)	100 mW avg, 100 m W pk	APC - 3.5mm (m)	Net: 0.2 kg (.38 lb) Shipping: 0.5 kg (1.0 lb)
Option 8485D-033	50 MHz to 33 GHz	26.5 GHz to 33 GHz: 1.35	-30 dBm to -20 dBm: (±2%)	100 mW avg, 100 m W pk	APC - 3.5mm (m)	Net: 0.2 kg (.38 lb) Shipping: 0.5 kg (1.0 lb)
8487D[3]	50 kHz to 50 GHz	0.05 GHz to 0.1 GHz: 1.19 0.1 GHz to 4 GHz: 1.15 2 GHz to 12.4 GHz: 1.20 12.4 GHz to 18 GHz: 1.29 18 GHz to 34 GHz: 1.37 34 GHz to 40 GHz: 1.61 40 GHz to 50 GHz: 1.89	-30 dBm to -20 dBm: (±2%)	100 mW avg, 100 m W pk 30 W.µs per pulse	2.4 mm (m)	Net: 0.2 kg (0.38 lb) Shipping: 0.5 kg (1.0 lb)
R8486D[3]	26.5 GHz to 40 GHz	26.5 GHz to 40 GHz: 1.40	-30 dBm to -25 dBm: (±3%) -25 dBm to -20 dBm: (±5%)	100 mW avg, or pk 40 V dc max	Waveguide flange UG-599/U	Net: 0.26 kg (0.53 lb) Shipping: .66 kg (1.3 lb)
Q8486D[3]	33 GHz to 50 GHz	33 GHz to 50 GHz: 1.40	-30 dBm to 25 dBm: (±3%) -25 dBm to -20 dBm: (±5%)	100 mW avg, or pk 40 V dc max	Waveguide flange UG-383/U	Net: 0.26 kg (0.53 lb) Shipping: 0.66 kg (1.3 lb)

1. Negligible deviation except for those power ranges noted.
2. For pulses greater than 30 W, the maximum average power (P_a) is limited by the energy per pulse (E) in W.µs according to $P_a = 30\text{-}0.02\ E$.
3. Includes 11708A 30 dB attenuator for calibrating against 0 dBm, 50 MHz power reference. The 11708A is factory set to 30 dB ±0.05 dB at 50 MHz, traceable to NIST. SWR < 1.05 at 50 MHz.

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