E-Series E9320 Power Sensor Specifications

The E9320 peak and average power sensors are designed for use with the EPM-P series power meters. The E9320 sensors have two measurement modes:

Normal mode	(default mode for E9320 sensors) for peak, average and time-related measurements
Average only mode	is designed primarily for average power measurements on low-level signals. This mode is the only mode used with 8480 and N8480 series sensors, E-series CW sensors and E-series E9300 sensors.

The following specifications are valid after zero and calibration of the power meter.

Note: E9320 power sensors MUST be used with an E9288A, B or C cable.

Table 3. Sensor specification

Sensor model	Video bandwidth	Frequency range	Power range		Maximum power	Connector type
			Average only mode	Normal mode[2]		
E9321A E9325A	300 kHz	50 MHz to 6 GHz 50 MHz to 18 GHz	–65 dBm to +20 dBm	–50 dBm to +20 dBm	+23 dBm average; +30 dBm peak (< 10 µsec duration)	Type N (m)
E9322A E9326A	1.5 MHz	50 MHz to 6 GHz 50 MHz to 18 GHz	–60 dBm to +20 dBm	–45 dBm to +20 dBm		
E9323A E9327A	5 MHz	50 MHz to 6 GHz 50 MHz to 18 GHz	–60 dBm to +20 dBm	–40 dBm to +20 dBm		

1. Options not available in all countries.
2. For average power measurements, free run acquisition.

The E9320 power sensors have two measurement ranges (lower and upper) as detailed in Table 4.

Table 4. Lower and upper measurement ranges

	E9321A/E9325A		E9322A/E9326A		E9323A/E9327A	
	Normal	Average only	Normal	Average only	Normal	Average only
Lower range (min. power)	–50 dBm	–65 dBm	–45 dBm	–60 dBm	–40 dBm	–60 dBm
Lower range (max. power) Lower to upper auto range point	+0.5 dBm	–17.5 dBm[1]	–5 dBm	–13.5 dBm1	–5 dBm	–10.5 dBm[1]
Upper to lower auto range point	–9.5 dBm	–18.5 dBm	–15 dBm	–14.5 dBm	–15 dBm	–11.5 dBm
Upper range (min. power)	–35 dBm	–50 dBm	–35 dBm	–45 dBm	–30 dBm	–35 dBm
Upper range (max. power)	+20 dBm	+20 dBm[1]	+20 dBm	+20 dBm[1]	+20 dBm	+20 dBm[1]

Table 5. Power sensor maximum SWR

Sensor model	Maximum SWR (< = 0 dBm)	
E9321A, E9325A	50 MHz to 2 GHz:	1.12
	2 GHz to 10 GHz:	1.16
	10 GHz to 16 GHz:	1.23
	16 GHz to 18 GHz:	1.28
E9322A, E9326A	50 MHz to 2 GHz:	1.12
	2 GHz to 12 GHz:	1.18
	12 GHz to 16 GHz:	1.21
	16 GHz to 18 GHz:	1.27
E9323A, E9327A	50 MHz to 2 GHz:	1.14
	2 GHz to 16 GHz:	1.22
	16 GHz to 18 GHz:	1.26

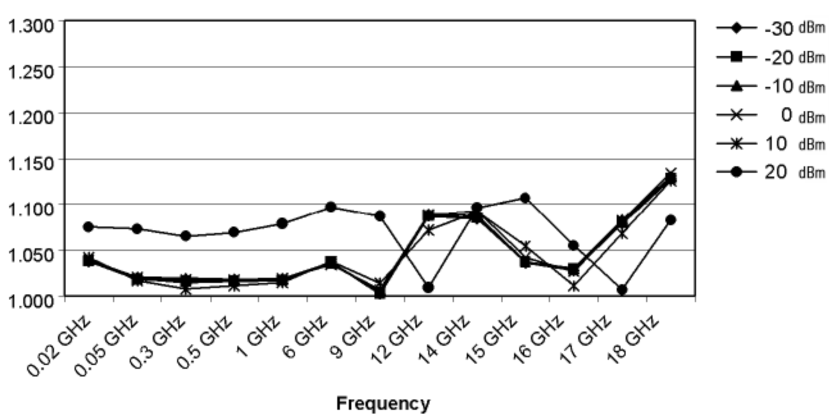

Figure 1. Typical SWR for the E9321A and E9325A sensors at various power levels

1. Applies to CW and constant amplitude signals only above –20 dBm.

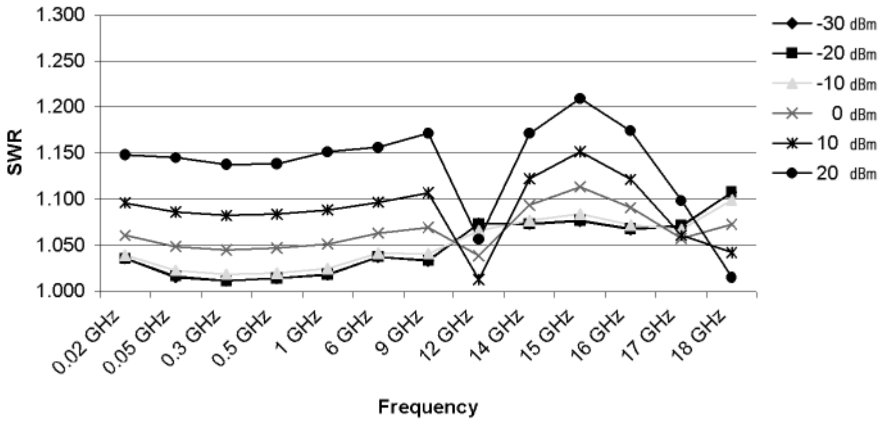

Figure 2. Typical SWR for the E9322A and E9326A sensors at various power levels

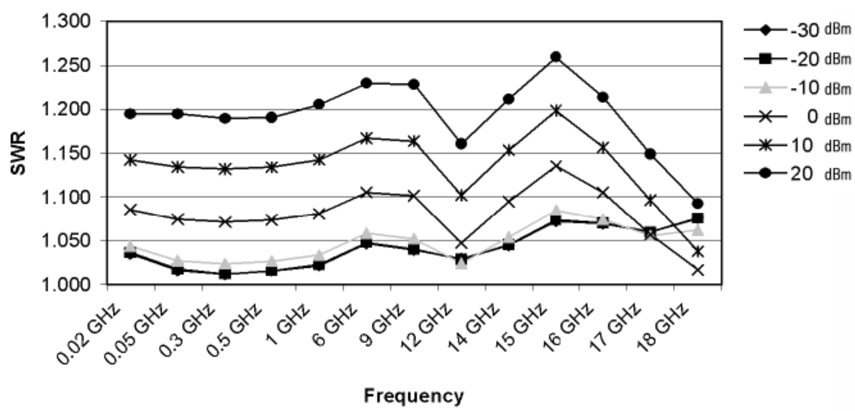

Figure 3. Typical SWR for the E9323A and E9327A sensors at various power levels

Sensor Linearity

Table 6a. Power sensor linearity, normal mode (upper and lower range).

Sensor model	Temperature (25 ± 10 °C)	Temperature (0 to 55 °C)
E9321A and E9325A	±4.2%	±5.0%
E9322A and E9326A	±4.2%	±5.0%
E9323A and E9327A	±4.2%	±5.0%

Table 6b. Power sensor linearity, average only mode (upper and lower range).

Sensor model	Temperature (25 ± 10 °C)	Temperature (0 to 55 °C)
E9321A and E9325A	±3.7%	±4.5%
E9322A and E9326A	±3.7%	±4.5%
E9323A and E9327A	±3.7%	±5.0 %

If the sensor temperature changes after calibration, and the meter and sensor is not re-calibrated, then the following additional linearity errors should be added to the linearity figures in Tables 6a and 6b.

Table 6c. Additional linearity error (normal and average only modes)

Sensor model	Temperature (25 ± 10 °C)	Temperature (0 to 55 °C)
E9321A and E9325A	±1.0%	±1.0%
E9322A and E9326A	±1.0%	±1.0%
E9323A and E9327A	±1.0%	±1.0%

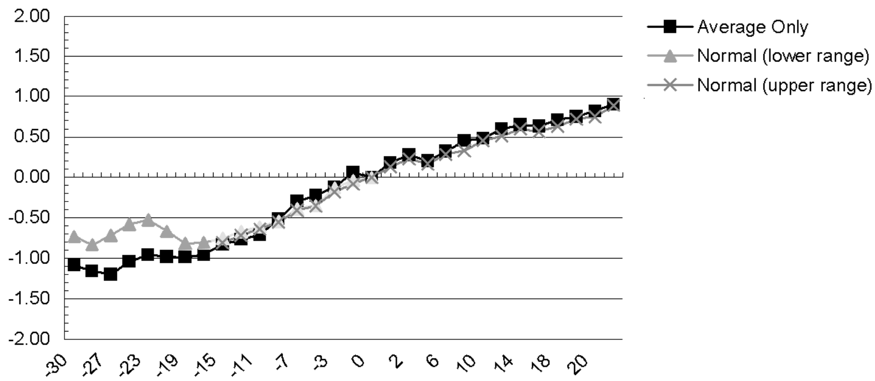

Figure 4. Typical power linearity at 25 °C for the E9323A and E9327A 5 MHz bandwidth sensors, after zero and calibration, with associated measurement uncertainty.

Table name????

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%

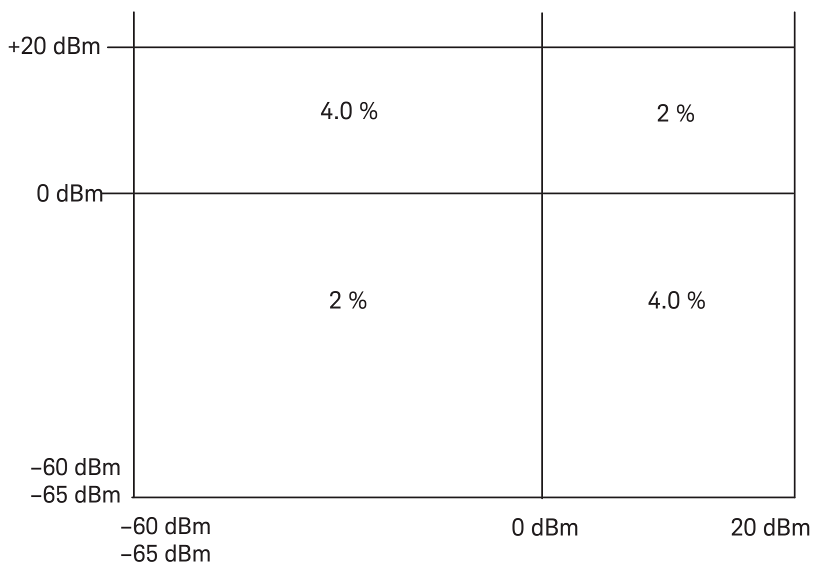

Figure 5. Relative mode power measurement linearity with an EPM-P series power meter, at 25 °C (typical).

Figure 5 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. It also assumes that negligible change in frequency and mismatch error occurs when transitioning from the power level used as the reference to the power level measured.

Peak Flatness

The peak flatness is the flatness of a peak-to-average ratio measurement for various tone-separations for an equal magnitude two-tone RF input. Figures 6, 7 and 8 refer to the relative error in peak-to-average measurement as the tone separation is varied. The measurements were performed at –10 dBm average power using an E9288A sensor cable (1.5 m).

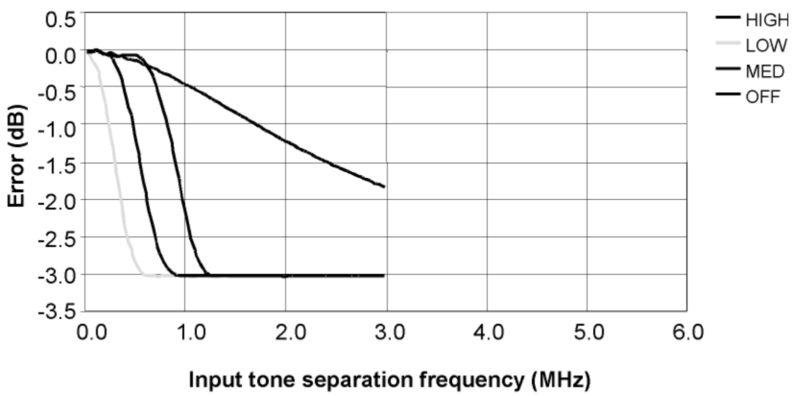

Figure 6. E9321A and E9325A Error in peak-to-average measurements for a two-tone input (high, medium, low and off filters).

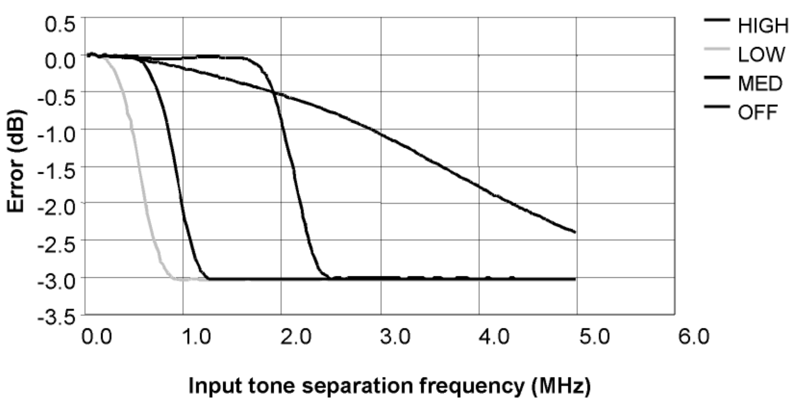

Figure 7. E9322A and E9326A error in peak-to-average measurements for a two-tone input (high, medium, low and off filters).

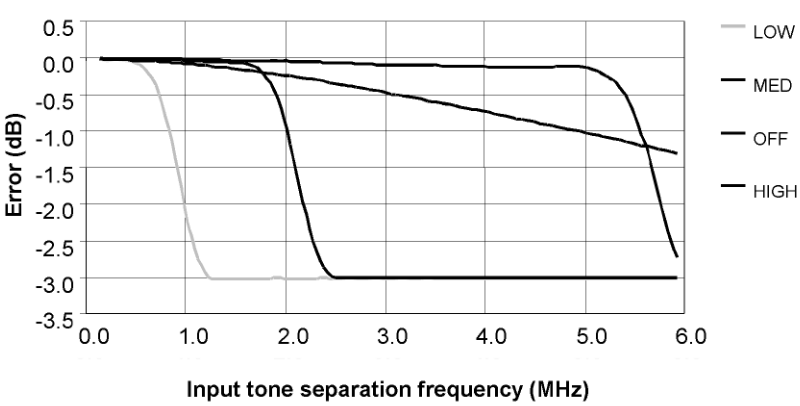

Figure 8. E9323A and E9327A error in peak-to-average measurements for a two-tone input (high, medium, low and off filters).

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 of the power sensor you are using. The CF corrects for the frequency response of the sensor. The EPM-P series power meter automatically reads the CF data stored in the sensor and uses it to make corrections.

For power levels greater than 0 dBm, add to the calibration factor uncertainty specification:

±0.1%/dB (for E9321A and E9325A sensors),
±0.15%/dB (for E9322A and E9326A sensors) and
±0.2%/dB (for E9323A and E9327A sensors).

Reflection Coefficient (Rho) relates to the SWR according to the formula:

SWR = (1 + Rho) / (1 – Rho)

Maximum uncertainties of the CF data are listed in Table 7. 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 7. Calibration factor uncertainty at 0.1 mW (–10 dBm).

Frequency	**Uncertainty (%) (25 ±10°C)**	**Uncertainty (%) (0 to 55°C)**
50 MHZ	Reference	Reference
100 MHz	±1.8	±2.0
300 MHz	±1.8	±2.0
500 MHz	±1.8	±2.0
800 MHz	±1.8	±2.0
1.0 GHz	±2.1	±2.3
1.2 GHz	±2.1	±2.3
1.5 GHz	±2.1	±2.3
2.0 GHz	±2.1	±2.3
3.0 GHz	±2.1	±2.3
4.0 GHz	±2.1	±2.3
5.0 GHz	±2.1	±2.3
6.0 GHz	±2.1	±2.3
7.0 GHz	±2.3	±2.5
8.0 GHz	±2.3	±2.5
9.0 GHz	±2.3	±2.5
10.0 GHz	±2.3	±2.5
11.0 GHz	±2.3	±2.5
12.0 GHz	±2.3	±2.5
12.4 GHz	±2.3	±2.5
13.0 GHz	±2.3	±2.5
14.0 GHz	±2.5	±2.8
15.0 GHz	±2.5	±2.8
16.0 GHz	±2.5	±2.8
17.0 GHz	±2.5	±2.8
18.0 GHz	±2.5	±2.8

Zero Set

This specification applies to a ZERO performed when the sensor input is not connected to the POWER REF.

Table 8. Zero set

Sensor model	Zero set (normal mode)	Zero set (average only mode)
E9321A, E9325A	5 nW	0.17 nW
E9322A, E9326A	19 nW	0.5 nW
E9323A, E9327A	60 nW	0.6 nW

Zero Drift and Measurement Noise

Table 9. Zero drift and measurement noise.

	Zero drift[1]		Measurement noise[2]		
Sensor model	Normal mode	Average only mode	Normal mode[3]	Normal mode[4]	Average only mode
E9321A, E9325A	< ±5 nW	< ±60 pW	< 6 nW	< 75 nW	< 165 pW
E9322A, E9326A	< ±5 nW	< ±100 pW	< 12 nW	< 180 nW	< 330 pW
E9323A, E9327A	< ±40 nW	< ±100 pW	< 25 nW	< 550 nW	< 400 pW

Effect of averaging on noise: Averaging over 1 to 1024 readings is available for reducing noise. Table 9 provides the measurement noise for a particular sensor. Use the noise multipliers in Table 10, for the appropriate speed (normal or x 2) or measurement mode (normal or average only) and the number of averages, to determine the total measurement noise value.

In addition, for x 2 speed (in normal mode) the total measurement noise should be multiplied by 1.2, and for fast speed (in normal mode), the multiplier is 3.4.

Note that in fast speed, no additional averaging is implemented.

Table 10. Noise multipliers

Mode	Number of averages	1	2	4	8	16	32	64	128	256	512	1024
Average-only	Noise multiplier (normal speed)	5.5	3.89	2.75	1.94	1.0	0.85	0.61	0.49	0.34	0.24	0.17
	Noise multiplier (x 2 speed)	6.5	4.6	3.25	2.3	1.63	1.0	0.72	0.57	0.41	0.29	0.2
Normal	Noise multiplier (normal speed; free run acquisition)	1.0	0.94	0.88	0.82	0.76	0.70	0.64	0.58	0.52	0.46	0.40

1. Within 1 hour after zero set, at a constant temperature, after a 24 hour warm-up of the power meter.
2. Measured over a one-minute interval, at a constant temperature, two standard deviations, with averaging set to 1 (for normal mode), 16 (for average only mode, normal speed) and 32 (for average only mode, x 2 speed).
3. In free run acquisition mode.
4. Noise per sample, video bandwidth set to OFF with no averaging (i.e. averaging set to 1) - see the note “Effect of Video Bandwidth Setting” and Table 11.

Example:
E9321A power sensor, number of averages = 4, free run acquisition, normal mode, x 2 speed.
Measurement noise calculation: (< 6 nW x 0.88 x 1.2) = < 6.34 nW

Effect of video bandwidth setting: The noise per sample is reduced by applying the meter video bandwidth reduction filter setting (High, Medium or Low). If averaging is implemented, this will dominate any effect of changing the video bandwidth.

Table 11. Effect of video bandwidth on noise per sample

Sensor	Noise multipliers		
	Low	Medium	High
E9321A, E9325A	0.32	0.50	0.63
E9322A, E9326A	0.50	0.63	0.80
E9323A, E9327A	0.40	0.63	1.0

Example:
E9322A power sensor, triggered acquisition, video band-width = High.
Noise per sample calculation: (< 180 nW x 0.80) = < 144 nW

Effect of time-gating on measurement noise

The measurement noise will depend on the time gate length, over which measurements are made. Effectively 20 averages are carried out every 1 us of gate length.

Settling Times

Average-only mode

In normal and x 2 speed, manual filter, 10 dB decreasing power step refer to Table 12.

Table 12. Settling time (average only mode)

Number of average	1	2	4	8	16	32	64	128	256	512	1024
Settling time(s) normal	0.08	0.13	0.24	0.45	1.1	1.9	3.5	6.7	14	27	57
Settling time(s) x 2	0.07	0.09	0.15	0.24	0.45	1.1	1.9	3.5	6.7	14	27

In fast speed, within the range –50 to +20 dBm, for a 10 dB decreasing power step, the settling time is 10 ms (for the E4416A) and 20 ms (for the E4417A).

When a power step crosses the power sensor's auto-range switch point, add 25 ms.

Normal mode

In normal, free run acquisition mode, within the range –20 to +20 dBm, for a 10 dB decreasing power step, the settling time is dominated by the measurement update rate and is listed in Table 13 for various filter settings.

Table 13. Settling time (normal mode)

Number of average	1	2	4	8	16	32	64	128	256	512	1024
Settling time free run acquisition, normal speed (s)	0.1	0.15	0.25	0.45	0.9	1.7	3.3	6.5	13.0	25.8	51.5
Settling time free run acquisition, X2 speed (s)	0.08	0.1	0.15	0.25	0.45	0.9	1.7	3.3	6.5	13.0	25.8

In normal mode, measuring in continuous or single acquisition mode, the performance of rise times, fall times and 99% settled results are shown in Table 14. Rise time and fall time specifications are for a 0.0 dBm pulse, with the rise time and fall time measured between 10% to 90% points and upper range selected.

Table 14. Rise and fall times versus sensor bandwidth[1]

Sensor mode, parameter	Video bandwidth setting			
	Low	Medium	High	Off
E9321A, Rise time (< µs)	2.6	1.5	0.9	0.3
E9325A, Fall time (< µs)	2.7	1.5	0.9	0.5
Settling Time (rising) (< µs)	5.1	5.1	4.5	0.6
Settling Time (falling) (< µs)	5.1	5.1	4.5	0.9
E9322A, Rise time (< µs)	1.5	0.9	0.4	0.2
E9326A, Fall time (< µs)	1.5	0.9	0.4	0.3
Settling Time (rising) (< µs)	5.3	4.5	3.5	0.5
Settling Time (falling) (< µs)	5.3	4.5	3.5	0.9
E9323A, Rise time (< µs)	0.9	0.4	0.2	0.2
E9327A, Fall time (< µs)	0.9	0.4	0.2	0.2
Settling Time (rising) (< µs)	4.5	3.5	1.5	0.4
Settling Time (falling) (< µs)	4.5	3.5	2	0.4

Overshoot in response to power steps with fast rise times, i.e. less than the sensor rise time, is < 10%. When a power step crosses the power sensor's auto-range switch point, add 10 µs.

1. Rise and fall time specifications are only valid when used with the E9288A sensor cable (1.5 meters).

Physical Specifications

Dimensions:	150 mm L x 38 mm W x 30 mm H (5.9 in x 1.5 in x 1.2 in)
Weight:	Net: 0.2 kg (0.45 lbs)
Shipping:	0.55 kg (1.2 lbs)

Ordering Information

E9321A	50 MHz to 6 GHz; 300 kHz BW
E9322A	50 MHz to 6 GHz; 1.5 MHz BW
E9323A	50 MHz to 6 GHz; 5 MHz BW
E9325A	50 MHz to 18 GHz; 300 kHz BW
E9326A	50 MHz to 18 GHz; 1.5 MHz BW
E9327A	50 MHz to 18 GHz; 5 MHz BW

Accessories Supplied

Operating and Service Guide (multi-language)

Power Sensor Options

E932xA-A6J	Supplies ANSI/NCSL Z540-1-1994 test data including measurement uncertainties
E932xA-1A7	Supplies ISO/ IEC 17025:2005 test data including measurement uncertainties
E932xA-0B1	Hard copy English language Operating and Service manual