

Agilent N1911A/N1912A P-Series Power Meters and N1921A/N1922A Wideband Power Sensors

Data sheet



Agilent Technologies

Specification Definitions

There are two types of product specifications:

Warranted specifications are specifications which are covered by the product warranty and apply over 0 to 55°C unless otherwise noted. Warranted specifications include measurement uncertainty calculated with a 95% confidence.

Characteristic specifications are specifications that are not warranted. They describe product performance that is useful in the application of the product. These characteristic specifications are shown in *italics*.

Characteristic information is representative of the product. In many cases, it may also be supplemental to a warranted specification. Characteristic specifications are not verified on all units. There are several types of characteristic specifications. These types can be placed in two groups:

One group of characteristic types describes 'attributes' common to all products of a given model or option. Examples of characteristics that describe 'attributes' are product weight, and 50 ohm input Type-N connector. In these examples product weight is an 'approximate' value and a 50ohm input is 'nominal'. These two terms are most widely used when describing a product's 'attributes'.

The second group describes 'statistically' the aggregate performance of the population of products.

These characteristics describe the expected behavior of the population of products. They do not guarantee the performance of any individual product. No measurement uncertainty value is accounted for in the specification. These specifications are referred to as 'typical'.

General Features

Number of channels	N1911A P-Series power meter, single channel N1912A P-Series power meter, dual channel
Frequency range	N1921A P-Series wideband power sensor, 50 MHz to 18 GHz N1922A P-Series wideband power sensor, 50 MHz to 40 GHz
Measurements	Average, peak and peak-to-average ratio power measurements are provided with free-run or time gated definition. Time parameter measurements of pulse rise time, fall time, pulse width, time to positive occurrence and time to negative occurrence are also provided.
Sensor compatibility	P-Series power meters are compatible with all Agilent P-Series wideband power sensors, E-series sensors and 8480 series power sensors ¹ Compatibility with the 8480 and E-series power sensors will be available in a future firmware release, free of charge.

1. Information contained in this document refers to operation with P-Series sensors. For specifications when used with 8480 and E-series sensors (except E9320A range), refer to Lit Number 5965-6382E. For specifications when used with E932XA sensors, refer to Lit Number 5980-1469E.

Conditions

The power meter and sensor will meet its specifications when:

- stored for a minimum of two hours at a stable temperature within the operating temperature range, and turned on for at least 30 minutes
- the power meter and sensor are within their recommended calibration period, and
- used in accordance to the information provided in the *User's Guide*.

P-Series Power Meter and Sensor

Key System Specifications and Characteristics²

Maximum sampling rate	100 Msamples/sec, continuous sampling
Video bandwidth	≥ 30 MHz
Single shot bandwidth	≥ 30 MHz
Rise time and fall time	≤ 13 ns (for frequencies ≥ 500 MHz) ³ , see Figure 1
Minimum pulse width	50 ns ⁴
Overshoot	≤ 5 % ³
Average power measurement accuracy	N1921A: ≤ ± 0.2 dB or ± 4.5 % ⁵ N1922A: ≤ ± 0.3 dB or ± 6.7 %
Dynamic range	-35 dBm to +20 dBm (> 500 MHz) -30 dBm to +20 dBm (50 MHz to 500 MHz)
Maximum capture length	1 second
Maximum pulse repetition rate	10 MHz (based on 10 samples per period)

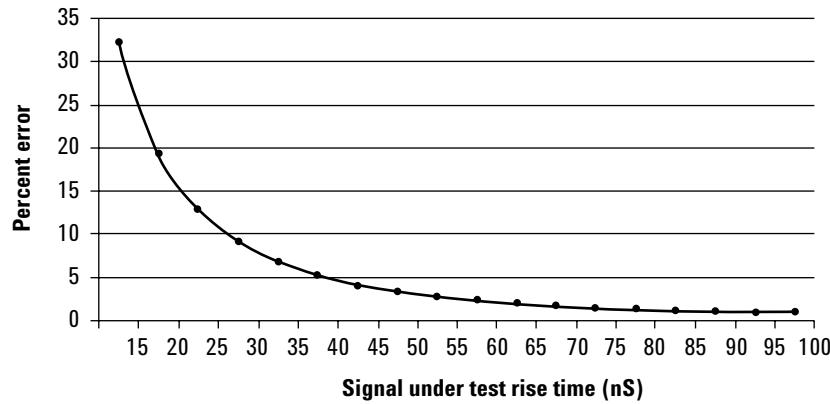


Figure 1. Measured rise time percentage error versus signal under test rise time

Although the rise time specification is ≤ 13 ns, this does not mean that the P-Series meter and sensor combination can accurately measure a signal with a known rise time of 13 ns. The measured rise time is the root sum of the squares (RSS) of the signal under test rise time and the system rise time (13 ns):

$$\text{Measured rise time} = \sqrt{(\text{signal under test rise time})^2 + (\text{system rise time})^2},$$

and the % error is:

$$\% \text{ Error} = ((\text{measured rise time} - \text{signal under test rise time}) / \text{signal under test rise time}) \times 100$$

2. See Appendix A on page 9 for measurement uncertainty calculations.
3. Specification applies only when the Off video bandwidth is selected.
4. The Minimum Pulse Width is the recommended minimum pulse width viewable on the power meter, where power measurements are meaningful and accurate, but not warranted.
5. Specification is valid over -15 to +20 dBm, and a frequency range 0.5 to 10 GHz, DUT Max. SWR < 1.27 for the N1921A, and a frequency range 0.5 to 40 GHz, DUT Max. SWR < 1.2 for the N1922A. Averaging set to 32, in Free Run mode.

P-Series Power Meter Specifications

Meter uncertainty

Instrumentation linearity	$\pm 0.8\%$
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Timebase

Timebase range	<i>2 ns to 100 msec/div</i>
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Accuracy	± 10 ppm
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Jitter	≤ 1 ns
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Trigger

Internal trigger

Range	-20 to $+20$ dBm
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Resolution	0.1 dB
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Level accuracy	± 0.5 dB
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Latency ⁶	160 ns ± 10 ns
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Jitter:	≤ 5 ns rms
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External TTL trigger input

High	> 2.4 V
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Low	< 0.7 V
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Latency ⁷	90 ns ± 10 ns
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Minimum trigger pulse width	15 ns
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Minimum trigger repetition period	50 ns
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Impedance	$50\ \Omega$
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Jitter	≤ 5 ns rms
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External TTL trigger output

Low to high transition on trigger event.

High	> 2.4 V
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Low	< 0.7 V
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Latency ⁸	30 ns ± 10 ns
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Impedance	$50\ \Omega$
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Jitter	≤ 5 ns rms
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Trigger delay

Delay range	± 1.0 s, maximum
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Delay resolution	1% of delay setting, 10 ns maximum
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Trigger hold-off

Range	$1\ \mu$ s to 400 ms
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Resolution	1% of selected value (to a minimum of 10 ns)
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Trigger level threshold hysteresis

Range	± 3 dB
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Resolution	0.05 dB
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6. Internal trigger latency is defined as the delay between the applied RF crossing the trigger level and the meter switching into the triggered state.

7. External trigger latency is defined as the delay between the applied trigger crossing the trigger level and the meter switching into the triggered state.

8. External trigger output latency is defined as the delay between the meter entering the triggered state and the output signal switching.

P-Series Wideband Power Sensor Specifications

The P-Series wideband power sensors are designed for use with the P-Series power meters only.

Sensor model	Frequency range	Dynamic range	Damage level	Connector type
N1921A	50 MHz to 18 GHz	-35 dBm to +20 dBm (≥ 500 MHz) -30 dBm to +20 dBm (50 MHz to 500 MHz)	+23 dBm (average power); +30 dBm (< 1 μ s duration) (peak power)	Type N (m)
N1922A	50 MHz to 40 GHz	-35 dBm to +20 dBm (≥ 500 MHz) -30 dBm to +20 dBm (50 MHz to 500 MHz)	+23 dBm (average power); +30 dBm (< 1 μ s duration) (peak power)	2.4mm (m)

Maximum SWR

Frequency band	N1921A /N1922A
50 MHz to 10 GHz	1.2
10 GHz to 18 GHz	1.26
18 GHz to 26.5GHz	1.3
26.5 GHz to 40 GHz	1.5

Sensor Calibration Uncertainty⁹

Definition: Uncertainty resulting from non-linearity in the sensor detection and correction process. This can be considered as a combination of traditional linearity, cal factor and temperature specifications and the uncertainty associated with the internal calibration process.

Frequency band	N1921A	N1922A
50 MHz to 500 MHz	4.5%	4.3%
500 MHz to 1 GHz	4.0%	4.2%
1 GHz to 10 GHz	4.0%	4.4%
10 GHz to 18 GHz	5.0%	4.7%
18 GHz to 26.5GHz		5.9%
26.5 GHz to 40 GHz		6.0%

Physical characteristics

Dimensions	N1921A	135 mm x 40 mm x 27 mm
	N1922A	127 mm x 40 mm x 27 mm
Weights with cable	Option 105	0.4 kg
	Option 106	0.6 kg
	Option 107	1.4 kg
Fixed sensor cable lengths	Standard	1.5 m (5-feet)
	Option 106	3.0 m (10-feet)
	Option 107	10 m (31-feet)

9. Beyond 70% Humidity, an additional 0.6% should be added to these values.

1 mW Power Reference

Note: The 1 mW power reference is provided for calibration of E-series and 8480 series sensors. The P-Series sensors are automatically calibrated do not need this reference for calibration

Power output	1.00 mW (0.0 dBm). Factory set to $\pm 0.4\%$ traceable to the National Physical Laboratory (NPL) UK
Accuracy (over 2-years)	$\pm 1.2\%$ (0 to 55° C) $\pm 0.4\%$ (25 \pm 10° C)
Frequency	50 MHz nominal
SWR	1.08 (0 to 55° C) 1.05 typical
Connector type	Type N (f), 50 Ω

Rear panel inputs/outputs

Recorder output	Analog 0-1 Volt, 1 k Ω output impedance, BNC connector. For dual channel instruments there will be two recorder outputs.
GPIB, 10/100BaseT LAN and USB2.0	Interfaces allow communication with an external controller.
Ground	Binding post, accepts 4 mm plug or bare-wire connection
Trigger input	Input has TTL compatible logic levels and uses a BNC connector.
Trigger output	Output provides TTL compatible logic levels and uses a BNC connector
Line Power	
Input voltage range	90 to 264 Vac, automatic selection
Input frequency range	47 to 63 Hz and 440 Hz
Power requirement	N1911A not exceeding 50 VA (30 Watts) N1912A not exceeding 75 VA (50 Watts)

Remote programming

Interface	GPIB interface operates to IEEE 488.2 and IEC65. 10/100BaseT LAN interface. USB 2.0 interface.
Command language	SCPI standard interface commands.
GPIB compatibility	SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP1, DC1, DT1, C0

Measurement speed

Measurement speed via remote interface ≥ 1500 readings per second

Regulatory information

Electromagnetic compatibility	Complies with the requirements of the EMC Directive 89/336/EEC.
Product safety	Conforms to the following product specifications: EN61010-1: 2001/IEC 1010-1:2001/CSA C22.2 No. 1010-1:1993 IEC 60825-1:1993/A2:2001/IEC 60825-1:1993+A1:1997+A2:2001 Low Voltage Directive 72/23/EEC

Physical characteristics

Dimensions	The following dimensions exclude front and rear panel protrusions:
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88.5 mm H x 212.6 mm W x 348.3 mm D (3.5 in x 8.5 in x 13.7 in)

Net weight	N1911A	≤ 3.5 kg (7.7 lb) approximate
	N1912A	≤ 3.7 kg (8.1 lb) approximate
Shipping weight	N1911A	≤ 7.9 kg (17.4 lb) approximate
	N1912A	≤ 8.0 kg (17.6 lb) approximate

Environmental conditions

General	Complies with the requirements of the EMC Directive 89/336/EEC.	
Operating		
Temperature	0° C to 55° C	
Maximum humidity	95% at 40° C (non-condensing)	
Minimum humidity	15% at 40° C (non-condensing)	
Maximum altitude	3,000 meters (9,840 feet)	
Storage		
Non-operating storage temperature	−30° C to +70° C	
Non-operating maximum humidity	90% at 65° C (non-condensing)	
Non-operating maximum altitude	15,420 meters (50,000 feet)	

System Specifications and Characteristics

The video bandwidth in the meter can be set to High, Medium, Low and Off. The video bandwidths stated in the table below are not the 3 dB bandwidths, as the video bandwidths are corrected for optimal flatness (except the Off filter). Refer to Figure 2 for information on the flatness response. The Off video bandwidth setting provides the warranted rise time and fall time specification and is the recommended setting for minimizing overshoot on pulse signals.

Dynamic response - rise time, fall time, and overshoot versus video bandwidth settings

Parameter	Video bandwidth setting			Off	
	Low: 5 MHz	Medium: 15 MHz	High: 30 MHz	< 500 MHz	> 500 MHz
Rise time/ fall time ¹⁰	< 56 ns	< 25 ns	≤ 13 ns	< 36 ns	≤ 13 ns
Overshoot ¹¹				< 5 %	< 5 %

For option 107 (10m cable), add 5 ns to the rise time and fall time specifications.

10. Specified as 10% to 90% for rise time and 90% to 10% for fall time on a 0 dBm pulse.

11. Specified as the overshoot relative to the settled pulse top power.

Characteristic 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. Figure 2 refers to the relative error in peak-to-average ratio measurements as the tone separation is varied. The measurements were performed at -10 dBm with power sensors with 1.5 m cable lengths.

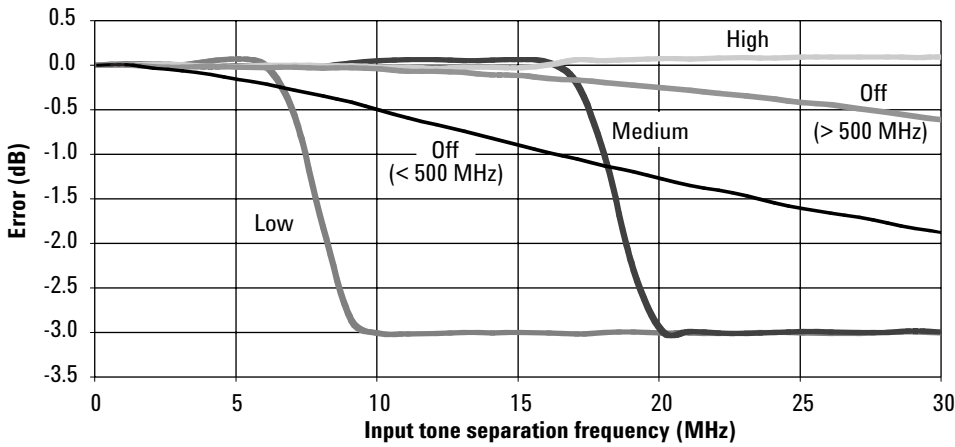


Figure 2. N192XA Error in peak-to-average measurements for a two-tone input (High, Medium, Low and Off filters)

Noise and drift

Sensor model	Zeroing	Zero set		Zero drift ¹²	Noise per sample	Measurement noise (Free run) ¹³
		<500 MHz	> 500 MHz			
N1921A /N1922A	No RF on input RF present	200 nW 550 nW	200 nW	100 nW	2 μW	50 nW

Measurement average setting	1	2	4	8	16	32	64	128	256	512	1024
Free run noise multiplier	1	0.9	0.8	0.7	0.6	0.5	0.45	0.4	0.3	0.25	0.2

Video BW setting		Low 5 MHz	Medium 15 MHz	High 30 MHz	Off
Noise per sample multiplier	< 500 MHz	0.5	1	2	1
	≥ 500 MHz	0.45	0.75	1.1	1

Effect of video bandwidth setting

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

Effect of time-gating on measurement noise

The measurement noise on a time-gated measurement will depend on the time gate length. 100 averages are carried out every 1 us of gate length. The Noise-per-Sample contribution in this mode can approximately be reduced by $\sqrt{(\text{gate length}/10 \text{ ns})}$ to a limit of 50 nW.

12. Within 1 hour after a zero, at a constant temperature, after 24 hour warm-up of the power meter. This component can be disregarded with Auto-zero mode set to ON.

13. Measured over a one-minute interval, at a constant temperature, two standard deviations, with averaging set to 1.

Appendix A

Uncertainty calculations for a power measurement (settled, average power)

[Specification values from this document are in **bold italic**, values calculated on this page are underlined.]

Process:

- 1. Power level:
- 2. Frequency:

- 3. Calculate meter uncertainty:
 Calculate noise contribution
 - If in Free Run mode, Noise = **Measurement noise x free run multiplier**
 - If in Trigger mode, Noise = **Noise-per-sample x noise per sample multiplier**

- Convert noise contribution to a relative term¹⁴ = Noise/Power
- Instrumentation linearity**
- Drift**
- RSS of above three terms => Meter uncertainty =

- 4. **Zero Uncertainty**
 (Mode and frequency dependent) = Zero set/Power =

- 5. Sensor calibration uncertainty
 (Sensor, frequency, power and temperature dependent) =

- 6. System contribution, coverage factor of 2 => sys_{rss} =
- (RSS three terms from steps 3, 4 and 5)

- 7. Standard uncertainty of mismatch
Max SWR (Frequency dependent) =
- convert to reflection coefficient, $|\rho_{\text{Sensor}}| = (\text{SWR}-1)/(\text{SWR}+1) =$
- Max DUT SWR (Frequency dependent) =
- convert to reflection coefficient, $|\rho_{\text{DUT}}| = (\text{SWR}-1)/(\text{SWR}+1) =$

- 8. Combined measurement uncertainty @ k=1

$$U_C = \sqrt{\left(\frac{\text{Max}(\rho_{\text{DUT}}) \cdot \text{Max}(\rho_{\text{Sensor}})}{\sqrt{2}}\right)^2 + \left(\frac{\text{sys}_{\text{rss}}}{2}\right)^2}$$

- Expanded uncertainty, k = 2, = U_C * 2 =

14. The noise to power ratio is capped for powers > 100 uW, in these cases use: Noise/100 μW.

Worked Example

Uncertainty calculations for a power measurement (settled, average power)

[Specification values from this document are in **bold italic**, values calculated on this page are underlined.]

Process:

- 1. Power level:

<i>1mW</i>

- 2. Frequency:

<i>1 GHz</i>

- 3. Calculate meter uncertainty: *In free run, auto zero mode average = 16*
 Calculate noise contribution
 - If in Free Run mode, **Noise** = **Measurement noise x free run multiplier** = *50 nW x 0.6 = 30 nW*
 - If in Trigger mode, **Noise** = **Noise-per-sample x noise per sample multiplier**

- Convert noise contribution to a relative term¹⁵ = **Noise/Power** = *30 nW/100 uW*

<u>0.03%</u>

- Instrumentation linearity**

<u>0.8%</u>

- Drift**

-

- RSS of above three terms => **Meter uncertainty** =

<u>0.8%</u>

- 4. **Zero Uncertainty**
 (Mode and frequency dependent) = **Zero set/Power** =

<u>0.03%</u>

300 nW/1 mW

- 5. Sensor calibration uncertainty
 (Sensor, frequency, power and temperature dependent) =

<u>4.0%</u>

- 6. **System contribution**, coverage factor of 2 => **sys_{rss}** =

<u>4.08%</u>

 (RSS three terms from steps 3, 4 and 5)

- 7. Standard uncertainty of mismatch
Max SWR (Frequency dependent) =

<u>1.25</u>

convert to reflection coefficient, $|\rho_{\text{Sensor}}| = (\text{SWR}-1)/(\text{SWR}+1) = \dots\dots\dots$

<u>0.111</u>

Max DUT SWR (Frequency dependent) =

<u>1.26</u>

convert to reflection coefficient, $|\rho_{\text{DUT}}| = (\text{SWR}-1)/(\text{SWR}+1) = \dots\dots\dots$

<u>0.115</u>

- 8. Combined measurement uncertainty @ k=1

$$U_C = \sqrt{\left(\frac{\text{Max}(\rho_{\text{DUT}}) \cdot \text{Max}(\rho_{\text{Sensor}})}{\sqrt{2}}\right)^2 + \left(\frac{\text{sys}_{\text{rss}}}{2}\right)^2} \dots\dots\dots$$

<u>2.23%</u>

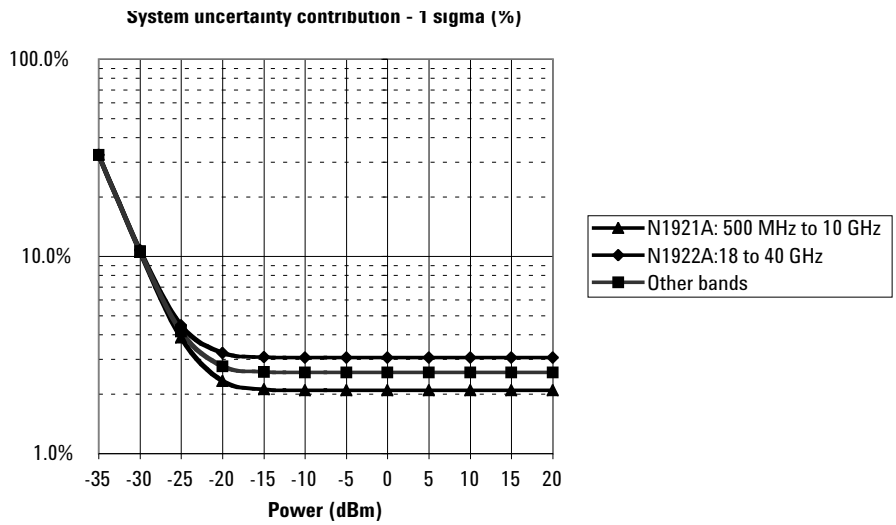
Expanded uncertainty, k = 2, = $U_C \cdot 2 = \dots\dots\dots$

<u>±4.46%</u>

15. The noise to power ratio is capped for powers > 100 uW, in these cases use: Noise/100 μW instead.

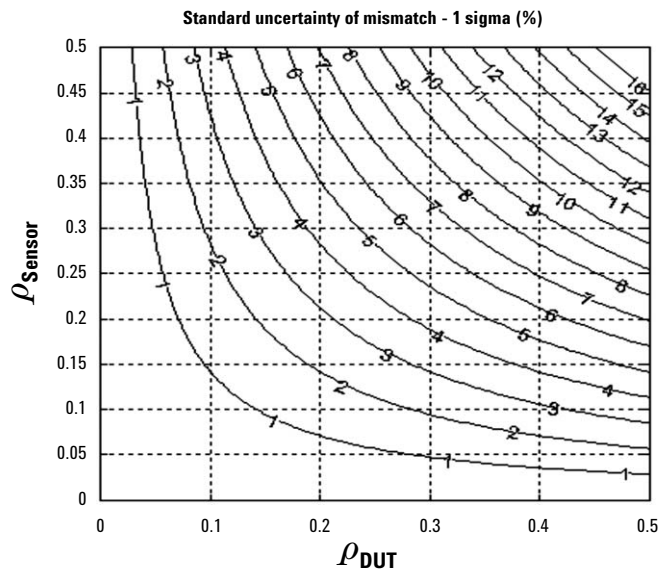
Graphical Example

A. System contribution to measurement uncertainty versus power level (equates to step 6 result/2)



Note: The above graph is valid for conditions of free-run operation, with a signal within the video bandwidth setting on the system. Humidity < 70%.

B. Standard uncertainty of mismatch.



SWR	ρ	SWR	ρ
1.0	0.00	1.8	0.29
1.05	0.02	1.90	0.31
1.10	0.05	2.00	0.33
1.15	0.07	2.10	0.35
1.20	0.09	2.20	0.38
1.25	0.11	2.30	0.39
1.30	0.13	2.40	0.41
1.35	0.15	2.50	0.43
1.40	0.17	2.60	0.44
1.45	0.18	2.70	0.46
1.5	0.20	2.80	0.47
1.6	0.23	2.90	0.49
1.7	0.26	3.00	0.50

Note: The above graph shows the Standard Uncertainty of Mismatch = $\rho_{DUT} \cdot \rho_{Sensor} / \sqrt{2}$, rather than the Mismatch Uncertainty Limits. This term assumes that both the Source and Load have uniform magnitude and uniform phase probability distributions.

C. Combine A & B

$$U_C = \sqrt{(Value\ from\ Graph\ A)^2 + (Value\ from\ Graph\ B)^2}$$

Expanded Uncertainty, $k = 2$, = $2 \cdot U_C = \dots\dots\dots \pm \dots\dots \%$

Related Literature List

P-Series Power Meters and Power Sensors, configuration guide, literature number 5989-1252EN

P-Series Power Meters and Power Sensors, technical overview, literature number 5989-1049EN

Related Web Resources

For information on the P-Series power meters and sensors, visit:
www.agilent.com/find/wideband_powermeters

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