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

Data sheet

Agilent Technologies

LXI Class-C-Compliant Power Meter

A P-series power meter is a LXI Class-C-compliant instrument, developed using LXI Technology. LXI, an acronym for LAN eXtension for Instrumentation, is an instrument standard for devices that use the Ethernet (LAN) as their primary communication interface.

Hence, it is an easy- to- use instrument especially with the usage of an integrated Web browser that provides a convenient way to configure the instrument's functionality.

Specification Definitions

There are two types of product specifications:

Warranted specifications are specifications which are covered by the product warranty and apply over a range of 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. They can be divided into 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 the product weight and '50-ohm input Type-N connector'. In these examples, product weight is an 'approximate' value and a 50-ohm input is 'nominal'. These two terms are most widely used when describing a product's 'attributes'.

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*.

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 definitions. 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 free-of-charge in firmware release Ax.03.01and above.

1. Information contained in this document refers to operations using P-series sensors. For specifications relating to the use of 8480 and E-series sensors (except E9320A range), refer to Lit Number 5965-6382E. For specifications relating to the use of E932XA sensors, refer to Lit Number 5980-1469E.

P-Series Power Meter and Sensor Key System Specifications and Characteristics[2]

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)*

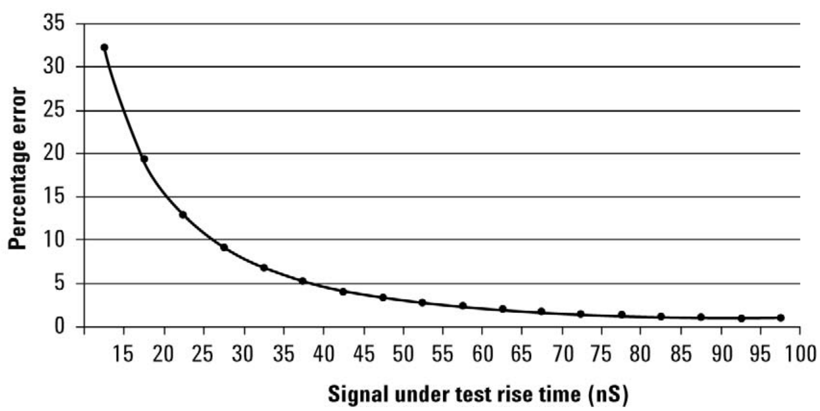


Figure 1. Measured rise time percentage error versus signal under test rise time

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):

Measured rise time = $\sqrt{(\text{signal under test rise time})^2 + (\text{system rise time})^2}$,
and the % error is:

% Error = ((measured rise time – signal under test rise time)/signal under test rise time) x 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 a range of –15 to +20 dBm, and a frequency range of 0.5 to 10 GHz, DUT Max. SWR < 1.27 for the N1921A, and a frequency range of 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	± 0.8 %

Timebase

Timebase range	*2 ns to 100 msec/div*
Accuracy	±10 ppm
Jitter	*≤ 1 ns*

Trigger

Internal trigger	
Range	*–20 to +20 dBm*
Resolution	*0.1 dB*
Level accuracy	*± 0.5 dB*
Latency[6]	*160 ns ± 10 ns*
Jitter:	*≤ 5 ns rms*
External TTL trigger input	
High	*> 2.4 V*
Low	*< 0.7 V*
Latency[7]	*90 ns ± 10 ns*
Minimum trigger pulse width	*15 ns*
Minimum trigger repetition period	*50 ns*
Maximum trigger voltage input	*15 V emf from 50 Ω dc (current < 100 mA), or* *60 V emf from 50 Ω (pulse width < 1 s, current < 100 mA)*
Impedance	*50 Ω*
Jitter	*≤ 5 ns rms*
External TTL trigger output	Low to high transition on trigger event
High	*> 2.4 V*
Low	*< 0.7 V*
Latency[8]	*30 ns ± 10 ns*
Impedance	*50 Ω*
Jitter	*≤ 5 ns rms*
Trigger delay	
Delay range	*± 1.0 s, maximum*
Delay resolution	*1 % of delay setting* *10 ns maximum*
Trigger hold-off	
Range	*1 μs to 400 ms*
Resolution	*1 % of selected value* *(to a minimum of 10 ns)*
Trigger level threshold hysteresis	
Range	*± 3 dB*
Resolution	*0.05 dB*

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 μs 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 μs duration) (peak power)	2.4 mm (m)

Maximum SWR

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

Sensor Calibration Uncertainty[9]

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 26.5 GHz		5.9 %
26.5 GHz to 40 GHz		6.0 %

Physical characteristics

Dimensions	N1921A	*135 mm x 40 mm x 27 mm (5.3 in x 1.6 in x 1.1 in)*
	N1922A	*127 mm x 40 mm x 27 mm (5.0 in x 1.6 in x 1.1 in)*
Weights with cable	Option 105	*0.4 kg (0.88 lb)*
	Option 106	*0.6 kg (1.32 lb)*
	Option 107	*1.4 kg (3.01 lb)*
Fixed sensor cable lengths	Option 105	*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 and therefore do not need this reference for calibration

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

Rear-panel inputs/outputs

Recorder output	Analog 0-1 Volt, 1 kΩ 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:

	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				
	Low: 5 MHz	Medium: 15 MHz	High: 30 MHz	Off	
				< 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.

Recorder Output and Video Output

The recorder output is used to output the corresponding voltage for the measurement a user sets on the Upper/Lower window of the power meter.

The video output is the direct signal output detected by the sensor diode, with no correction applied. The video output provides a DC voltage proportional to the measured input power through a BNC connector on the rear panel. The DC voltage can be displayed on an oscilloscope for time measurement. This option replaces the recorder output on the rear panel. The video output impedance is 50 ohm.

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.

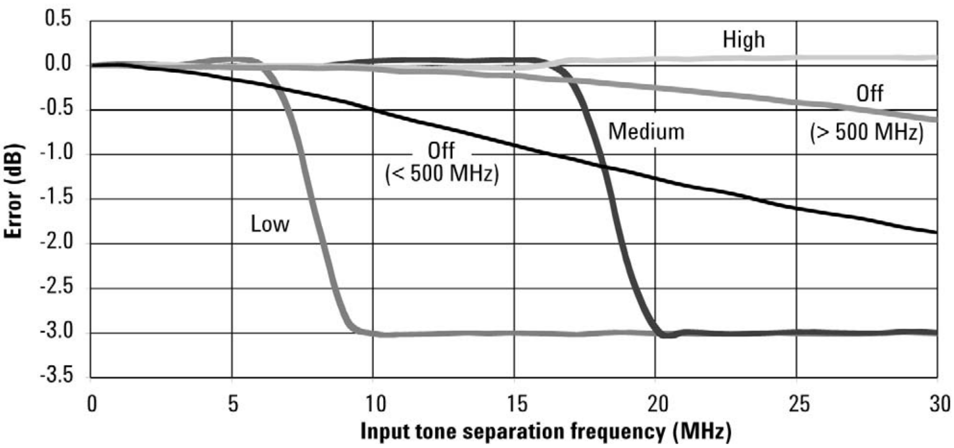


Figure 2. N192XA Error in peak-to-average measurements for a two-tone input (High, Medium, Low and Off filters)

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	200 nW		*100 nW*	*2 µW*	*50 nW*
	RF present	*550 nW*	200 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 µs of gate length. The Noise-per-Sample contribution in this mode can approximately be reduced by √(gate length/10 ns) to a limit of 50 nW.

12. Within 1 hour after a zero, at a constant temperature, after 24 hours 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 <u>underlined</u>.]

Process:

1. Power level: .... [W]
2. Frequency: .... [ ]

3. Calculate meter uncertainty:

   Calculate noise contribution

   - If in Free Run mode, <u>Noise</u> = ***Measurement noise x free run multiplier***
   - If in Trigger mode, <u>Noise</u> = ***Noise-per-sample x noise per sample multiplier***

Convert noise contribution to a relative term[14] = <u>Noise</u>/<u>Power</u> .... [%]

Instrumentation linearity .... [%]

Drift .... [%]

RSS of above three terms => <u>Meter uncertainty</u> = ... [%]

4. ***Zero Uncertainty***

   (Mode and frequency-dependent) = Zero set/<u>Power</u> = ... [%]

5. Sensor calibration uncertainty

   (Sensor, frequency, power and temperature-dependent) = ... [%]

6. <u>System contribution</u>, 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, $|\rho_{Sensor}|$ = (SWR–1)/(SWR+1) = ... [ ]

   Max DUT SWR (Frequency dependent) = ... [ ]

   convert to reflection coefficient, $|\rho_{DUT}|$ = (SWR–1)/(SWR+1) = ... [ ]

8. Combined measurement uncertainty @ k=1

$$U_C = \sqrt{\left(\frac{Max(\rho_{DUT}) \cdot Max(\rho_{Sensor})}{\sqrt{2}}\right)^2 + \left(\frac{sys_{rss}}{2}\right)^2}$$ .... [%]

   Expanded uncertainty, k = 2, = $U_C \cdot 2$ = ... [%]

14. The noise-to-power ratio is capped for powers > 100 µW, 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 <u>underlined</u>.]

Process:

1. Power level:	*1 mW*
2. Frequency:	*1 GHz*

3. Calculate meter uncertainty: *In free run, auto zero mode average = 16*

Calculate noise contribution

- If in Free Run mode, <u>Noise</u> = ***Measurement noise x free run multiplier*** = *50 nW x 0.6 = 30 nW*
- If in Trigger mode, <u>Noise</u> = ***Noise-per-sample x noise per sample multiplier***

Convert noise contribution to a relative term[15] = <u>Noise</u>/<u>Power</u> = *30 nW/100 µW*	*0.03 %*
Instrumentation linearity	*0.8 %*
Drift	–
RSS of above three terms => <u>Meter uncertainty</u> =	*0.8 %*

4. ***Zero Uncertainty***

(Mode and frequency dependent) = Zero set/<u>Power</u> = *300 nW/1 mW*	*0.03 %*

5. Sensor calibration uncertainty

(Sensor, frequency, power and temperature-dependent) =	*4.0 %*

6. <u>System contribution</u>, coverage factor of 2 => sys_{rss} = (RSS three terms from steps 3, 4 and 5)	*4.08 %*

7. Standard uncertainty of mismatch

Max SWR (Frequency-dependent) =	*1.25*
convert to reflection coefficient, $\lvert \rho_{Sensor} \rvert$ = (SWR–1)/(SWR+1) =	*0.111*
Max DUT SWR (Frequency-dependent) =	*1.26*
convert to reflection coefficient, $\lvert \rho_{DUT} \rvert$ = (SWR–1)/(SWR+1) =	*0.115*

8. Combined measurement uncertainty @ k = 1

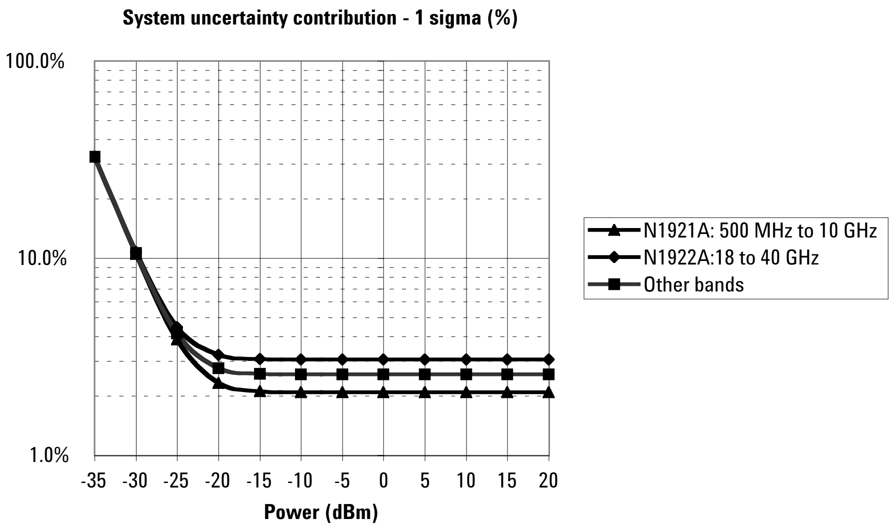
$$U_C = \sqrt{\left(\frac{Max(\rho_{DUT}) \cdot Max(\rho_{Sensor})}{\sqrt{2}}\right)^2 + \left(\frac{sys_{rss}}{2}\right)^2} \quad \ldots\ 2.23\ \%$$

Expanded uncertainty, k = 2, = $U_C \cdot 2$ =	*±4.46 %*

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

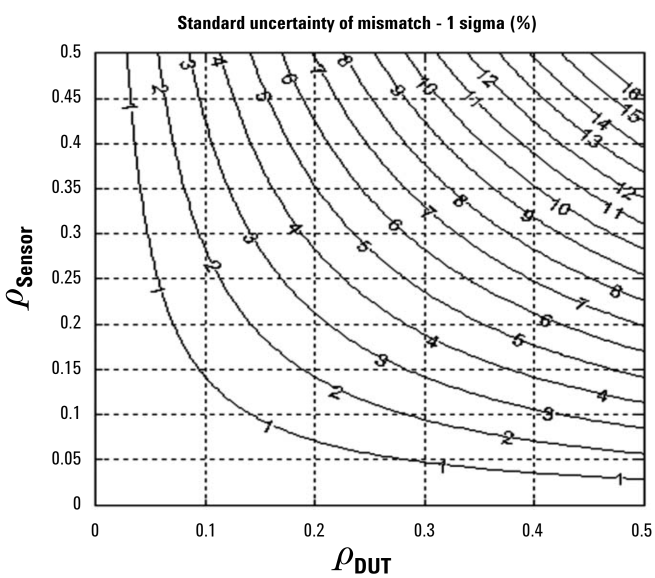
Graphical Example

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 = ρDUT. ρSensor / $\sqrt{2}$, 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. U_C = ... ± %

Related Literature

P-Series Power Meters and Power Sensors, Technical Overview, literature number 5989-1049EN

P-Series Power Meters and Power Sensors, Configuration Guide, literature number 5989-1252EN

E2094N IO Libraries Suite 14.0, Data Sheet, literature number 5989-1439EN

EPM-P Series Power Meters and E9320 Peak and Average Power Sensors, Data Sheet, literature number 5980-1469E

EPM Series Power Meters, E-Series, and 8480 Series Power Sensors, Data Sheet, literature number 5965-6382E

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