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Roos Instruments, Inc.
2285 Martin Avenue
Santa Clara, California 95050
United States of America
www.roos.com
408-748-8589

## 1.0 Purpose/Objective

This document outlines the measurement capabilities and an estimation of measurement uncertainties and/or errors for calibration with the Roos Instruments, Inc. manufacturing and field service operations.

## 2.0 General Scope

The electronic and physical measurement limitations and characteristics of the Roos Instruments calibration transfer standards are used in all manufacturing and field service operations. Values shown represent best measurement capabilities.

## 3.0 Definitions

3.1 Calibration: A set of procedures that when executed establish under specific conditions the relationship between the values indicated by a measuring instrument and the corresponding know characteristics of a particular transfer standard.

3.2 Transfer Standard: A physical or electrical device that has its performance characteristics measured, documented and compared to a know reference at Primary calibration laboratory such as US National Institute of Science and Technology (NIST).

3.3. Measurement Uncertainty: Calculated estimation of maximum errors possible in measurement accuracy at a specific point or function for a given measuring instrument.

For more information:
roos.com/support

# 4. DC/Low Frequency Transfer Standards

## 4.1 Fluke 87IV Multimeter

| Measurements | Uncertainty Label | Uncertainty Value |
| --- | --- | --- |
| Voltage DC | Maximum voltage | 1000 V |
| | Accuracy | ±(0.05% + 1) |
| | Maximum resolution | 10 µV |
| Voltage AC | Maximum voltage | 1000 V |
| | Accuracy | ±(0.7% + 2) True RMS |
| | AC bandwidth | 20 kHz with low pass filter; 3 db @ 1 kHz |
| | Maximum resolution | 0.1 mV |
| Current DC | Maximum amps | 10 A (20 A for 30 seconds maximum) |
| | Amps accuracy | ±(0.2% + 2) |
| | Maximum resolution | 0.01 µA |
| Current AC | Maximum amps | 10 A (20 A for 30 seconds maximum) |
| | Amps accuracy | ±(1.0% + 2) True RMS |
| | Maximum resolution | 0.1 µA |
| Resistance | Maximum resistance | 50 MΩ |
| | Accuracy | ±(0.2% + 1) |
| | Maximum resolution | 0.1 Ω |
| Capacitance | Maximum capacitance | 9,999 µF |
| | accuracy | ±(1% + 2) |
| | Maximum resolution | 0.01 nF |
| Frequency | Maximum frequency | 200 kHz |
| | Accuracy | ±(0.005% + 1) |
| | Maximum resolution | 0.01 Hz |
| Duty cycle | Maximum duty cycle | 99.9% |
| | Accuracy | ±(0.2% per khz + 0.1%) |
| | Maximum resolution | 0.1% |
| Temperature measurement | -200.0°C –1090°C<br>-328.0°F –1994.0°F excluding probe | |
| 80 BK temperature probe | -40.0°C –260°C<br>-40.0°F –500°F, 2.2°C or 2% whichever is greater | |

| Measurements | Uncertainty Label | Uncertainty Value |
|---|---|---|
| Conductance | Maximum conductance | 60.00 nS |
| | Accuracy | ±(1.0% + 10) |
| | Maximum resolution | 0.01 nS |
| Diode | Range | 3 V |
| | Resolution | 1 mV |
| | Accuracy | ±(2% + 1) |
| Duty cycle range | Accuracy | Within ±(0.2% per kHz + 0.1%) |

| Environmental Specifications | |
|---|---|
| Operating temperature | -°C to + 55°C |
| Storage temperature | -°C to + 60°C |
| Humidity (without condensation) | 0% – 90% (0°C – 35°C)<br>0% – 70% (35°C – 55°C) |
| Operating Altitude | 2000 m |

| Safety Specifications | |
|---|---|
| Overvoltage category | EN 61010 to 1000 V CAT III, 600V CAT IV |
| Agency approvals | UL, CSA, TÜV, VDE listed |

# 5.0 RF Transfer Standards up to 40 GHz

## 5.1 Spanawave/Gigatronics 8541C RF Power Meter with Spanawave/Gigatronics 80324A Power Sensor

The accuracy calculation table lists the significant uncertainties of an absolute power measurement. The accuracy of the 8541C combined with the 80324A sensor is shown at +20 dBm, 0 dBm, and -30 dBm; Frequency = 1 GHz; Source Match = 1.5:1.

| Measurements | Uncertainty at 1 GHz, 1.5:1 Source Match | | |
|---|---|---|---|
| 8541C with 80324A | @ 20 dBm | @ 0 dBm | @ -30 dBm |
| Instrumentation Uncertainty | ±5.2% | ±0% | ±0.925% |
| Sensor Power Linearity (>8 GHz) | ±0% | ±0% | ±0% |
| Calibrator Uncertainty | ±1.2% | ±1.2% | ±1.2% |
| Calibrator/Sensor Mismatch | ±0.28% | ±0.28% | ±0.28% |
| Calibration Factor Uncertainty | ±1.04% | ±1.04% | ±1.04% |
| Zero Error | ±0.00000005% | ±0.00000005% | ±0.005% |
| Noise | ±0.00000005% | ±0.00000005% | ±0.005% |
| Mismatch (Sensor/Source) | ±2.25% | ±2.25% | ±2.25% |
| % Total Uncertainty | ±9.97% | ±4.77% | ±5.71% |
| dB Total Uncertainty | ±0.41 dB | ±0.20 dB | ±0.24 dB |

### 5.2 Micronetics NS346KA RF Noise Power Source

| Measurements | Uncertainty |
|---|---|
| RF Frequency | 100 MHz to 40000 MHz |
| Noise Output | 10 - 17 dB ENR |
| Noise Spectral Density | -160.5 dBm/Hz |
| VSWR | 1.25:1 Max (5 - 12 GHz) |
| | 1.30:1 Max (12 - 18 GHz) |
| | 1.40:1 Max (18 - 26.5 GHz) |
| | 1.50:1 Max (26.5 - 40 GHz) |

### 5.3 Anritsu SC7777 Open Short Load Standards (OSL K-Connector)

| Measurements | Uncertainty Label | Uncertainty Value |
|---|---|---|
| Reference Plane Pin Depth | FEMALE | 0.207 ±0.003 inches<br>(5.2578 ±0.0762 mm) |
| | MALE | -0.207 ±0.003 inches<br>(-5.2578 ±0.0762 mm) |

## 6.0 V-Band Transfer Standards 50-75 GHz

### 6.1 Keysight N1913A 80 GHz RF Power Meter with Keysight V8486A 50-75 GHz Power Sensor

The accuracy calculation table lists the significant uncertainties of an absolute power measurement. The accuracy of the N1913A combined with the V8486A sensor is shown at +20 dBm, 0 dBm, and -26 dBm; Frequency = 65 GHz; VSWR = 1.5:1.

Calculator Source Link: https://community.keysight.com/servlet/JiveServlet/download/71731-1-6558/Absolute+Power+Sensor+Uncertainty.xlsx

*Revision 10*
*Date updated: 7 Sep 2017*

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The data used in this calculator is based on the specifications in the EPM, EPM and P-Series datasheets.
The calculations are based on the ISO Guide to the Expression of Uncertainty in Measurement, often referred to as the GUM.
For more info about the GUM, and models used in this calculator, please refer to Agilent Application Note 1449-3,
"Fundamentals of RF and Microwave Power Measurements (Part 3)," literature number 5988-9215EN.

### 65 GHz @ +20 dBm

**Keysight Average Power Sensor Uncertainty Calculator**

Instructions: Fill in all the blue-colored fields and the "Sensor Match" box; observe results in lower right.

| Input | Value | | Match Specification Style† | Distribution of ρ† | |
|---|---|---|---|---|---|
| Device Under Test match (RL or SWR or ρ)* | 1.22 | VSWR | Maximum | C: Rayleigh | |
| Sensor Model | E8486A-100 | | Maximum | C: Rayleigh | |
| User-Entered Sensor Match* | 1.50 | VSWR | Maximum | C: Rayleigh | |
| Sensor Match at Measurement Frequency: Data Source is<br>○ From Sensor Model (via Specifications vs. Frequency)<br>◉ User-Entered; use the line above this box | | | †These two columns set the form of the specification and the PDF of the match. Hover below for details. | | |
| Power Meter Model | EPM | | | | |
| Frequency | 80 | GHz | | | |
| Power | 20 | dBm | | 0.1 | W |
| Number of Readings Averaged | 1 | | | | |
| Average mode | Normal | | | | |

| Source of Uncertainty | Symbol | Value ± | Probability Distribution | Divisor | Result |
|---|---|---|---|---|---|
| Mismatch Gain Between Generator and Sensor | $M_u$ | \|Γmax\|g = 0.099<br>\|Γmax\|s = 0.200 | C: Rayleigh<br>C: Rayleigh | 4.179 | 0.474% |
| Mismatch Gain Between Calibration Source and Sensor | $M_{uc}$ | \|Γ\|c = 0.029<br>\|Γmax\|sc = 0.032 | A: Uniform inside Circle<br>C: Rayleigh | 2.431 | 0.038% |
| Power Meter Instrumentation Error | $P_m$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Power Meter Instrumentation Error During Calibration | $P_{mc}$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Power Meter Calibrator Output Power | $P_{cal}$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Zero Drift | D | 4.000E-08 | Gaussian | 2.000 | 0.000% |
| Power Sensor Calibration Factor Uncertainties | $K_b$ | 5.300% | Gaussian | 2.000 | 2.650% |
| Power Sensor Linearity | $P_l$ | 2.000% | Gaussian | 2.000 | 1.000% |
| Zero Set | $Z_s$ | 2.000E-07 | Gaussian | 2.000 | 0.000% |
| Sensor Noise | N | 4.500E-07 | Gaussian | 2.000 | 0.001% |
| | | | | Combined Uncertainty-RSSed = | 2.90% |
| | | | | K = | 2.00 |
| | | | | **Expanded Uncertainty =** | 5.81% |
| | | | | Upper Limit Uncertainty = | + 0.245dB |
| | | | | Lower Limit Uncertainty = | − 0.260dB |

* This term can be entered as the return loss (RL) in dB (Sxx), or VSWR, or as a reflection coefficient.
e.g. RL = -15 dB is equivalent to VSWR = 1.43 is equivalent to ρ = 0.178 (reflection coefficient)
Enter 1 for VSWR = 1, a perfect match, or 0 for RL = 0 dB, a lossless reflection

## 65 GHz @ 0 dBm

| | | | | | |
|---|---|---|---|---|---|
| **Keysight Average Power Sensor Uncertainty Calculator** | | | Instructions: Fill in all the blue-colored fields and the "Sensor Match" box; observe results in lower right. | | |
| **Input** | **Value** | | **Match Specification Style**† | **Distribution of ρ**† | |
| **Device Under Test match (RL or SWR or ρ)*** | 1.22 | VSWR | Maximum | C: Rayleigh | |
| **Sensor Model** | E8486A-100 | | Maximum | C: Rayleigh | |
| **User-Entered Sensor Match*** | 1.50 | VSWR | Maximum | C: Rayleigh | |
| Sensor Match at Measurement Frequency: Data Source is<br>○ From Sensor Model (via Specifications vs. Frequency)<br>◉ User-Entered; use the line above this box | | | †These two columns set the form of the specification and the PDF of the match. Hover below for details. | | |
| **Power Meter Model** | EPM | | | | |
| **Frequency** | 80 | GHz | | | |
| **Power** | 0 | dBm | | 0.001 | W |
| **Number of Readings Averaged** | 1 | | | | |
| **Average mode** | Normal | | | | |
| **Source of Uncertainty** | **Symbol** | **Value ±** | **Probability Distribution** | **Divisor** | **Result** |
| Mismatch Gain Between Generator and Sensor | $M_u$ | \|Γmax\|g = 0.099<br>\|Γmax\|s = 0.200 | C: Rayleigh<br>C: Rayleigh | 4.179 | 0.474% |
| Mismatch Gain Between Calibration Source and Sensor | $M_{uc}$ | \|Γ\|c = 0.029<br>\|Γmax\|sc = 0.032 | A: Uniform inside Circle<br>C: Rayleigh | 2.431 | 0.038% |
| Power Meter Instrumentation Error | $P_m$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Power Meter Instrumentation Error During Calibration | $P_{mc}$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Power Meter Calibrator Output Power | $P_{cal}$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Zero Drift | D | 4.000E-08 | Gaussian | 2.000 | 0.002% |
| Power Sensor Calibration Factor Uncertainties | $K_b$ | 5.300% | Gaussian | 2.000 | 2.650% |
| Power Sensor Linearity | $P_l$ | 1.000% | Gaussian | 2.000 | 0.500% |
| Zero Set | $Z_s$ | 2.000E-07 | Gaussian | 2.000 | 0.010% |
| Sensor Noise | N | 4.500E-07 | Gaussian | 2.000 | 0.124% |
| | | | | Combined Uncertainty-RSSed = | 2.78% |
| | | | | K = | 2.00 |
| * This term can be entered as the return loss (RL) in dB (Sxx), or VSWR, or as a reflection coefficient. | | | | **Expanded Uncertainty =** | **5.55%** |
| e.g. RL = -15 dB is equivalent to VSWR = 1.43 is equivalent to ρ = 0.178 (reflection coefficient) | | | | Upper Limit Uncertainty = | + 0.235dB |
| Enter 1 for VSWR = 1, a perfect match, or 0 for RL = 0 dB, a lossless reflection | | | | Lower Limit Uncertainty = | − 0.248dB |

### 65 GHz @ -26 dBm

**Keysight Average Power Sensor Uncertainty Calculator**

Instructions: Fill in all the blue-colored fields and the "Sensor Match" box; observe results in lower right.

| Input | Value | | Match Specification Style[†] | Distribution of ρ[†] | |
|---|---|---|---|---|---|
| Device Under Test match (RL or SWR or ρ)* | 1.22 | VSWR | Maximum | C: Rayleigh | |
| Sensor Model | E8486A-100 | | Maximum | C: Rayleigh | |
| User-Entered Sensor Match* | 1.50 | VSWR | Maximum | C: Rayleigh | |
| Power Meter Model | EPM | | | | |
| Frequency | 80 | GHz | | | |
| Power | -26 | dBm | | 2.51189E-06 | W |
| Number of Readings Averaged | 1 | | | | |
| Average mode | Normal | | | | |

Sensor Match at Measurement Frequency: Data Source is
- ○ From Sensor Model (via Specifications vs. Frequency)
- ◉ User-Entered; use the line above this box

[†]These two columns set the form of the specification and the PDF of the match. Hover below for details.

| Source of Uncertainty | Symbol | Value ± | Probability Distribution | Divisor | Result |
|---|---|---|---|---|---|
| Mismatch Gain Between Generator and Sensor | $M_u$ | $\lvert\Gamma max\rvert g$ = 0.099<br>$\lvert\Gamma max\rvert s$ = 0.200 | C: Rayleigh<br>C: Rayleigh | 4.179 | 0.474% |
| Mismatch Gain Between Calibration Source and Sensor | $M_{uc}$ | $\lvert\Gamma\rvert c$ = 0.029<br>$\lvert\Gamma max\rvert sc$ = 0.032 | A: Uniform inside Circle<br>C: Rayleigh | 2.431 | 0.038% |
| Power Meter Instrumentation Error | $P_m$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Power Meter Instrumentation Error During Calibration | $P_{mc}$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Power Meter Calibrator Output Power | $P_{cal}$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Zero Drift | D | 4.000E-08 | Gaussian | 2.000 | 0.796% |
| Power Sensor Calibration Factor Uncertainties | $K_b$ | 5.300% | Gaussian | 2.000 | 2.650% |
| Power Sensor Linearity | $P_l$ | 1.000% | Gaussian | 2.000 | 0.500% |
| Zero Set | $Z_s$ | 2.000E-07 | Gaussian | 2.000 | 3.981% |
| Sensor Noise | N | 4.500E-07 | Gaussian | 2.000 | 49.266% |
| | | | | Combined Uncertainty-RSSed = | 49.51% |
| | | | | K = | 2.00 |
| | | | | **Expanded Uncertainty =** | **99.02%** |
| | | | | Upper Limit Uncertainty = | + 2.989dB |
| | | | | Lower Limit Uncertainty = | − 20.092dB |

* This term can be entered as the return loss (RL) in dB (Sxx), or VSWR, or as a reflection coefficient.
e.g. RL = -15 dB is equivalent to VSWR = 1.43 is equivalent to ρ = 0.178 (reflection coefficient)
Enter 1 for VSWR = 1, a perfect match, or 0 for RL = 0 dB, a lossless reflection

## 6.2 OML WR15 Waveguide Offset Standards

| +25 C | MIN | TYP | MAX |
|---|---|---|---|
| System Operating Frequency (WR-15)[1] | 50 GHz | -- | 75 GHz |
| Length of Shim (1/4 wavelength) | | .0635 +/- .0002 in | |
| Return Loss of Fixed Load, Adjustable Load | -- | >35 dB | -- |
| Damage Level | -- | +13 dBm | -- |
| Operating Temperature Range | +20 °C | +25 °C | +30 °C |

[1]Test Port Flange Configuration is compatible with MIL-DTL-3922/67D (UG387/U-M)

# 7.0 E-Band Transfer Standards 60-88 GHz

## 7.1 Keysight N1913A 80 GHz RF Power Meter with Keysight E8486A-100 60-90 GHz Power Sensor

The accuracy calculation table lists the significant uncertainties of an absolute power measurement. The accuracy of the N1913A combined with the E8486A sensor is shown at +20 dBm, 0 dBm, and -26 dBm; Frequency = 80 GHz; VSWR = 1.5:1.

Calculator Source Link: https://community.keysight.com/servlet/JiveServlet/download/71731-1-6558/Absolute+Power+Sensor+Uncertainty.xlsx

*Revision 10*
*Date updated: 7 Sep 2017*

**© Keysight Technologies, Inc. 2012, 2014 and 2015.**
The data used in this calculator is based on the specifications in the EPM, EPM and P-Series datasheets.
The calculations are based on the ISO Guide to the Expression of Uncertainty in Measurement, often referred to as the GUM.
For more info about the GUM, and models used in this calculator, please refer to Agilent Application Note 1449-3,
"Fundamentals of RF and Microwave Power Measurements (Part 3)," literature number 5988-9215EN.

### +20 dBm @ 80 GHz

**Keysight Average Power Sensor Uncertainty Calculator**

Instructions: Fill in all the blue-colored fields and the "Sensor Match" box; observe results in lower right.

| Input | Value | | Match Specification Style† | Distribution of ρ† |
|---|---|---|---|---|
| Device Under Test match (RL or SWR or ρ)* | 1.22 | VSWR | Maximum | C: Rayleigh |
| Sensor Model | E8486A-100 | | Maximum | C: Rayleigh |
| User-Entered Sensor Match* | 1.50 | VSWR | Maximum | C: Rayleigh |

Sensor Match at Measurement Frequency: Data Source is
- ◯ From Sensor Model (via Specifications vs. Frequency)
- ◉ User-Entered; use the line above this box

†These two columns set the form of the specification and the PDF of the match. Hover below for details.

| | | | | |
|---|---|---|---|---|
| Power Meter Model | EPM | | | |
| Frequency | 80 | GHz | | |
| Power | 20 | dBm | 0.1 | W |
| Number of Readings Averaged | 1 | | | |
| Average mode | Normal | | | |

| Source of Uncertainty | Symbol | Value ± | Probability Distribution | Divisor | Result |
|---|---|---|---|---|---|
| Mismatch Gain Between Generator and Sensor | $M_u$ | \|Γmax\|g = 0.099<br>\|Γmax\|s = 0.200 | C: Rayleigh<br>C: Rayleigh | 4.179 | 0.474% |
| Mismatch Gain Between Calibration Source and Sensor | $M_{uc}$ | \|Γ\|c = 0.029<br>\|Γmax\|sc = 0.032 | A: Uniform inside Circle<br>C: Rayleigh | 2.431 | 0.038% |
| Power Meter Instrumentation Error | $P_m$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Power Meter Instrumentation Error During Calibration | $P_{mc}$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Power Meter Calibrator Output Power | $P_{cal}$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Zero Drift | D | 4.000E-08 | Gaussian | 2.000 | 0.000% |
| Power Sensor Calibration Factor Uncertainties | $K_b$ | 5.300% | Gaussian | 2.000 | 2.650% |
| Power Sensor Linearity | $P_l$ | 2.000% | Gaussian | 2.000 | 1.000% |
| Zero Set | $Z_s$ | 2.000E-07 | Gaussian | 2.000 | 0.000% |
| Sensor Noise | N | 4.500E-07 | Gaussian | 2.000 | 0.001% |
| | | | | Combined Uncertainty-RSSed = | 2.90% |
| | | | | K = | 2.00 |
| | | | | Expanded Uncertainty = | **5.81%** |
| | | | | Upper Limit Uncertainty = | + 0.245dB |
| | | | | Lower Limit Uncertainty = | − 0.260dB |

* This term can be entered as the return loss (RL) in dB (Sxx), or VSWR, or as a reflection coefficient.
e.g. RL = -15 dB is equivalent to VSWR = 1.43 is equivalent to ρ = 0.178 (reflection coefficient)
Enter 1 for VSWR = 1, a perfect match, or 0 for RL = 0 dB, a lossless reflection

## 0 dBm @ 80 GHz

**Keysight Average Power Sensor Uncertainty Calculator**

Instructions: Fill in all the blue-colored fields and the "Sensor Match" box; observe results in lower right.

| **Input** | **Value** | | **Match Specification Style**[†] | **Distribution of ρ**[†] | |
|---|---|---|---|---|---|
| **Device Under Test match (RL or SWR or ρ)*** | 1.22 | VSWR | Maximum | C: Rayleigh | |
| **Sensor Model** | E8486A-100 | | Maximum | C: Rayleigh | |
| **User-Entered Sensor Match*** | 1.50 | VSWR | Maximum | C: Rayleigh | |
| Sensor Match at Measurement Frequency: Data Source is<br>○ From Sensor Model (via Specifications vs. Frequency)<br>◉ User-Entered; use the line above this box | | | [†]These two columns set the form of the specification and the PDF of the match. Hover below for details. | | |
| **Power Meter Model** | EPM | | | | |
| **Frequency** | 80 | GHz | | | |
| **Power** | 0 | dBm | | 0.001 | W |
| **Number of Readings Averaged** | 1 | | | | |
| **Average mode** | Normal | | | | |

| **Source of Uncertainty** | **Symbol** | **Value ±** | **Probability Distribution** | **Divisor** | **Result** |
|---|---|---|---|---|---|
| Mismatch Gain Between Generator and Sensor | $M_u$ | $\vert\Gamma max\vert g$ = 0.099<br>$\vert\Gamma max\vert s$ = 0.200 | C: Rayleigh<br>C: Rayleigh | 4.179 | 0.474% |
| Mismatch Gain Between Calibration Source and Sensor | $M_{uc}$ | $\vert\Gamma\vert c$ = 0.029<br>$\vert\Gamma max\vert sc$ = 0.032 | A: Uniform inside Circle<br>C: Rayleigh | 2.431 | 0.038% |
| Power Meter Instrumentation Error | $P_m$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Power Meter Instrumentation Error During Calibration | $P_{mc}$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Power Meter Calibrator Output Power | $P_{cal}$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Zero Drift | D | 4.000E-08 | Gaussian | 2.000 | 0.002% |
| Power Sensor Calibration Factor Uncertainties | $K_b$ | 5.300% | Gaussian | 2.000 | 2.650% |
| Power Sensor Linearity | $P_l$ | 1.000% | Gaussian | 2.000 | 0.500% |
| Zero Set | $Z_s$ | 2.000E-07 | Gaussian | 2.000 | 0.010% |
| Sensor Noise | N | 4.500E-07 | Gaussian | 2.000 | 0.124% |
| | | | | Combined Uncertainty-RSSed = | 2.78% |
| | | | | K = | 2.00 |
| | | | | **Expanded Uncertainty =** | 5.55% |
| | | | | Upper Limit Uncertainty = | + 0.235dB |
| | | | | Lower Limit Uncertainty = | − 0.248dB |

* This term can be entered as the return loss (RL) in dB (Sxx), or VSWR, or as a reflection coefficient.
e.g. RL = -15 dB is equivalent to VSWR = 1.43 is equivalent to ρ = 0.178 (reflection coefficient)
Enter 1 for VSWR = 1, a perfect match, or 0 for RL = 0 dB, a lossless reflection

## -26 dBm @ 80 GHz

**Keysight Average Power Sensor Uncertainty Calculator**

Instructions: Fill in all the blue-colored fields and the "Sensor Match" box; observe results in lower right.

| Input | Value | | Match Specification Style[†] | Distribution of ρ[†] |
|---|---|---|---|---|
| Device Under Test match (RL or SWR or ρ)* | 1.22 | VSWR | Maximum | C: Rayleigh |
| Sensor Model | E8486A-100 | | Maximum | C: Rayleigh |
| User-Entered Sensor Match* | 1.50 | VSWR | Maximum | C: Rayleigh |

Sensor Match at Measurement Frequency: Data Source is
- ◯ From Sensor Model (via Specifications vs. Frequency)
- ◉ User-Entered; use the line above this box

[†]These two columns set the form of the specification and the PDF of the match. Hover below for details.

| | | | | |
|---|---|---|---|---|
| Power Meter Model | EPM | | | |
| Frequency | 80 | GHz | | |
| Power | -26 | dBm | 2.51189E-06 | W |
| Number of Readings Averaged | 1 | | | |
| Average mode | Normal | | | |

| Source of Uncertainty | Symbol | Value ± | Probability Distribution | Divisor | Result |
|---|---|---|---|---|---|
| Mismatch Gain Between Generator and Sensor | $M_u$ | \|Γmax\|g = 0.099<br>\|Γmax\|s = 0.200 | C: Rayleigh<br>C: Rayleigh | 4.179 | 0.474% |
| Mismatch Gain Between Calibration Source and Sensor | $M_{uc}$ | \|Γ\|c = 0.029<br>\|Γmax\|sc = 0.032 | A: Uniform inside Circle<br>C: Rayleigh | 2.431 | 0.038% |
| Power Meter Instrumentation Error | $P_m$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Power Meter Instrumentation Error During Calibration | $P_{mc}$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Power Meter Calibrator Output Power | $P_{cal}$ | 0.50% | Gaussian | 2.000 | 0.250% |
| Zero Drift | D | 4.000E-08 | Gaussian | 2.000 | 0.796% |
| Power Sensor Calibration Factor Uncertainties | $K_b$ | 5.300% | Gaussian | 2.000 | 2.650% |
| Power Sensor Linearity | $P_l$ | 1.000% | Gaussian | 2.000 | 0.500% |
| Zero Set | $Z_s$ | 2.000E-07 | Gaussian | 2.000 | 3.981% |
| Sensor Noise | N | 4.500E-07 | Gaussian | 2.000 | 49.266% |
| | | | | Combined Uncertainty-RSSed = | 49.51% |
| | | | | K = | 2.00 |
| | | | | **Expanded Uncertainty =** | **99.02%** |
| | | | | Upper Limit Uncertainty = | + 2.989dB |
| | | | | Lower Limit Uncertainty = | − 20.092dB |

* This term can be entered as the return loss (RL) in dB (Sxx), or VSWR, or as a reflection coefficient.
e.g. RL = -15 dB is equivalent to VSWR = 1.43 is equivalent to ρ = 0.178 (reflection coefficient)
Enter 1 for VSWR = 1, a perfect match, or 0 for RL = 0 dB, a lossless reflection

## 7.2 OML WR12 Waveguide Offset Standards

| +25 C | MIN | TYP | MAX |
|---|---|---|---|
| System Operating Frequency (WR-12)[1] | 60 GHz | -- | 90 GHz |
| Length of Shim (1/4 wavelength) | | .0533 +/- .0002 in | |
| Return Loss of Fixed Load, Adjustable Load | -- | >35 dB | -- |
| Damage Level | -- | +13 dBm | -- |
| Operating Temperature Range | +20 °C | +25 °C | +30 °C |

[1]Test Port Flange Configuration is compatible with MIL-DTL-3922/67D (UG387/U-M)