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LABORATORY ACCREDITATION

ACCREDITED LABORATORY

A2LA has accredited

AGILENT TECHNOLOGIES ROSEVILLE SUPPORT OPERATION Roseville, CA

for technical competence in the field of **Calibration**

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General Requirements for the Competence of Testing and Calibration Laboratories*. This laboratory also meets the requirements of ANSI/NCSL Z540-1-1994 and any additional program requirements in the field of calibration. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated 18 June 2005*).

Presented this 2nd day of April 2008.

A handwritten signature in cursive script, reading "Peter Abney", positioned above a horizontal line.

President
For the Accreditation Council
Certificate Number 1920.01
Valid to February 28, 2010



For the calibrations to which this accreditation applies, please refer to the laboratory's Calibration Scope of Accreditation.

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005
& ANSI/NCSL Z540-1-1994

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CALIBRATION

Valid To: February 28, 2010

Certificate Number: 1920.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations¹:

Roseville Support Operations

I. Electrical – DC/Low Frequency

| Parameter/Equipment | Range | Best Uncertainty ^{2,4,5} (\pm) | Comments |
|------------------------------------|---|--|--------------------------------|
| DC Voltage – Generate ³ | (0 to 0.22) V (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V | 3.8 μ V/V + 2.5 μ V 4.9 μ V/V + 1.9 μ V 3.3 μ V/V + 4.7 μ V 2.4 μ V/V + 48 μ V 5.4 μ V/V + 40 μ V 6.9 μ V/V + 520 μ V | Fluke 5720A/ 5725A |
| Fixed Values | 10 V | 3 μ V/V | Fluke 732A |
| DC Voltage – Measure ³ | (0 to 0.1) V (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1000) V | 5.6 μ V/V + 1.5 μ V 5.2 μ V/V + 1.2 μ V 4.7 μ V/V + 2.5 μ V 6.6 μ V/V + 45 μ V 19 μ V/V + 160 μ V | HP 3458A/100 PLC option 002 |

| Parameter/Equipment | Range | Best Uncertainty ^{2,4,5} (\pm) | Comments |
|---|--|--|------------------------------|
| DC Current – Generate ³ | (0 to 220) μ A 220 μ A to 2.2 mA (2.2 to 22) mA (22 to 100) mA (100 to 220) mA | 36 μ V/V + 0.009 μ V 33 μ V/V + 0.008 μ V 34 μ V/V + 0.040 μ V 42 μ V/V + 0.68 μ V 51 μ V/V + 0.00 μ V | Fluke 5720A |
| | 220 mA to 1 A (1 to 2.2) A (2.2 to 11) A | 76 μ V/V + 12 μ V 150 μ V/V - 66 μ V 300 μ V/V + 400 μ V | Fluke 5720A/5725A |
| DC Current – Measure ³ | (10 to 100) μ A 100 μ A to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1.1 A | 20 μ A/A + 0 μ A 20 μ A/A + 0.1 μ A 20 μ A/A + 0.06 μ A 35 μ A/A + 0.60 μ A 0.011 % + 11 μ A | HP 3458A |
| Resistance – Generate, Fixed Points ³ | 0 Ω 1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 k Ω 1.9 k Ω 10 k Ω 19 k Ω 100 k Ω 190 k Ω 1 M Ω 1.9 M Ω 10 M Ω 19 M Ω 100 M Ω | 0.25 m Ω 0.27 m Ω 0.31 m Ω 0.34 m Ω 2.5 m Ω 2.7 m Ω 3.3 m Ω 9.3 m Ω 31 m Ω 93 m Ω 0.19 Ω 1.2 Ω 2.2 Ω 20 Ω 42 Ω 400 Ω 1.5 k Ω 12 k Ω | Fluke 5720A |
| | 1 Ω 10 k Ω | 8 $\mu\Omega/\Omega$ 4 $\mu\Omega/\Omega$ (trend \pm 1 $\mu\Omega/\Omega$) | Fluke 742-1 Fluke 742-10k |
| Resistance – Measure ³ | (0 to 10) Ω (10 to 100) Ω 100 to 1 k Ω (1 to 10) k Ω (10 to 100) k Ω 100 k Ω to 1 M Ω (1 to 10) M Ω (10 to 100) M Ω 100 M Ω to 1 G Ω | 18 $\mu\Omega/\Omega$ + 74 $\mu\Omega$ 13 $\mu\Omega/\Omega$ + 740 $\mu\Omega$ 11 $\mu\Omega/\Omega$ + 7.6 $\mu\Omega$ 11 $\mu\Omega/\Omega$ + 74 $\mu\Omega$ 11 $\mu\Omega/\Omega$ + 740 $\mu\Omega$ 15 $\mu\Omega/\Omega$ + 2.4 $\mu\Omega$ 53 $\mu\Omega/\Omega$ + 110 $\mu\Omega$ 0.05 % + 4.3 k Ω 0.5 % + 290 k Ω | HP 3458A |

| Parameter/Range | Frequency | Best Uncertainty ^{2,4,5} (±) | Comments |
|------------------------------------|---|--|-------------|
| AC Current – Generate ³ | | | |
| (0 to 220) μA | (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.016 % + 0.063 μA 89 μA/A + 0.062 μA 60 μA/A + 0.062 μA 0.018 % + 0.062 μA 0.10 % + 0.09 μA | Fluke 5720A |
| 220 μA to 2.2 mA | (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.027 % + 0.056 μA 0.020 % + 0.051 μA 0.016 % + 0.052 μA 0.023 % + 0.12 μA 0.11 % + 0.67 μA | |
| (2.2 to 22) mA | (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.027 % + 0.56 μA 0.021 % + 0.51 μA 0.016 % + 0.52 μA 0.023 % + 0.71 μA 0.11 % + 5.1 μA | |
| (22 to 220) mA | (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.028 % + 3.9 μA 0.021 % + 3.0 μA 0.017 % + 2.2 μA 0.024 % + 3.1 μA 0.11 % + 0.01 mA | |
| 220 mA to 2.2 A | 20 Hz to 1 kHz 220 mA to 1.0 A >1 A to 2.2 A (1 to 5) kHz 220 mA to 1.0 A >1 A to 2.2 A (5 to 10) kHz | 0.030 % + 32 μA 0.035 % + 26 μA 0.044 % + 83 μA 0.055 % + 72 μA 0.67 % + 0.072 mA | |
| (2.2 to 11) A | 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.044 % + 130 μA 0.088 % + 290 μA 0.31 % + 0.64 mA | |
| AC Current – Measure ³ | | | |
| (0 to 100) μA | (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz | 0.4 % + 31 nA 0.15 % + 31 nA 0.06 % + 31 nA | HP 3458A |
| (0.1 to 1) mA | (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz | 0.4 % + 310 nA 0.15 % + 210 nA 0.06 % + 210 nA | |

| Parameter/Range | Frequency | Best Uncertainty ^{2,4,5} (\pm) | Comments |
|---|--|---|-------------|
| AC Current – Measure (cont) ³ | | | |
| (1 to 10) mA | (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz | 0.4 % + 3.1 μ A 0.15 % + 2.1 μ A 0.06 % + 2.1 μ A | HP 3458A |
| (10 to 100) mA | (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz | 0.4 % + 31 μ A 0.15 % + 21 μ A 0.06 % + 21 μ A | |
| 100 mA to 1.05 A | (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz | 0.4 % + 220 μ A 0.16 % + 220 μ A 0.08 % + 220 μ A 0.1 % + 220 μ A | |
| AC Voltage – Generate ³ | | | |
| (0 to 22) mV | (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz | 0.027 % + 4.5 μ V 0.013 % + 4.5 μ V 0.011 % + 4.5 μ V 0.027 % + 4.5 μ V 0.054 % + 5.3 μ V 0.12 % + 10 μ V 0.17 % + 24 μ V 0.30 % + 24 μ V | Fluke 5720A |
| (22 to 220) mV | (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz | 0.025 % + 12 μ V 95 μ V/V + 7.3 μ V 86 μ V/V + 7.3 μ V 0.018 % + 9.4 μ V 0.049 % + 16 μ V 0.088 % + 20 μ V 0.14 % + 0.033 mV 0.27 % + 0.048 mV | |
| 220 mV to 2.2 V | (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz | 0.025 % + 39 μ V 99 μ V/V + 15 μ V 63 μ V/V + 5.9 μ V 86 μ V/V + 8.3 μ V 0.011 % + 30 μ V 0.041 % + 78 μ V 0.99 % + 200 μ V 0.16 % + 0.32 mV | |

| Parameter/Range | Frequency | Best Uncertainty ^{2,4,5} (\pm) | Comments |
|--|--|--|--------------------|
| AC Voltage – Generate (cont) ³ | | | |
| (2.2 to 22) V | (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz | 0.026 % + 420 μ V 0.011 % + 150 μ V 67 μ V/V + 44 μ V 91 μ V/V + 90 μ V 0.011 % + 210 μ V 0.029 % + 650 μ V 0.11 % + 2.0 mV 0.16 % + 3.3 mV | Fluke 5720A |
| (22 to 220) V | (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (>22 to 100) Vrms (>100 to 220) Vrms (50 to 100) kHz (>22 to 100) Vrms (>100 to 220) Vrms (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz | 0.024 % + 3.9 mV 0.010 % + 1.5 mV 69 μ V/V + 430 μ V 98 μ V/V + 910 μ V 0.017 % + 560 μ V 0.016 % + 2.4 mV 0.021 % + 1.9 mV 0.087 % + 16 mV 0.43 % + 39 mV 0.79 % + 79 mV | |
| (0 to 250) V max output, 1100 V range | (15 to 50) Hz 50 Hz to 1 kHz | 0.031 % + 17 mV 91 μ V/V + 2.9 mV | Fluke 5720A/ 5725A |
| (0 to 250) V max output, 1100 V range | 40 Hz to 20 kHz (20 to 30) kHz | 91 μ V/V + 2.9 mV 0.051 % + 9.6 mV | |
| (0 to 750) V | (30 to 50) kHz (50 to 100) kHz | 0.052 % + 8.6 mV 0.19 % + 37 mV | |
| AC Voltage – Measure ³ | | | |
| (0 to 10) mV | (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 4) MHz (4 to 8) MHz | 0.03 % + 3.1 μ V 0.02 % + 1.2 μ V 0.03 % + 1.7 μ V 0.1 % + 1.6 μ V 0.5 % + 1.3 μ V 4 % + 2.1 μ V 1.2 % + 6.6 μ V 7 % + 7.5 μ V 20 % + 8.2 μ V | HP 3458A |

| Parameter/Range | Frequency | Best Uncertainty ^{2, 5, 11} (\pm) | Comments |
|---|---|---|----------|
| AC Voltage – Measure (cont) ³ | | | |
| (10 to 100) mV | (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz (2 to 4) MHz (4 to 8) MHz (8 to 10) MHz | 70 μ V/V + 4.1 μ V 70 μ V/V + 2.1 μ V 0.014 % + 2.3 μ V 0.03 % + 2.6 μ V 0.08 % + 2.3 μ V 0.3 % + 15 μ V 1 % + 28 μ V 1.5 % + 20 μ V 4 % + 74 μ V 4 % + 83 μ V 15 % + 110 μ V | HP 3458A |
| 100 mV to 1 V | (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz (2 to 4) MHz (4 to 8) MHz (8 to 10) MHz | 70 μ V/V + 41 μ V 70 μ V/V + 21 μ V 0.014 % + 22 μ V 0.03 % + 22 μ V 0.08 % + 22 μ V 0.3 % + 120 μ V 1 % + 300 μ V 1.5 % + 210 μ V 4 % + 730 μ V 4 % + 830 μ V 15 % + 1 mV | |
| (1 to 10) V | (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz (2 to 4) MHz (4 to 8) MHz (8 to 10) MHz | 70 μ V/V + 420 μ V 70 μ V/V + 220 μ V 0.014 % + 240 μ V 0.03 % + 250 μ V 0.08 % + 220 μ V 0.3 % + 1.1 mV 1 % + 1.1 mV 1.5 % + 1.1 mV 4 % + 7.1 mV 4 % + 8.1 mV 15 % + 11 mV | |
| (10 to 100) V | (1 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz | 0.02 % + 4.1 mV 0.02 % + 2.6 mV 0.035 % + 2.4 mV 0.12 % + 2.1 mV 0.4 % + 11 mV 1.5 % + 40 mV | |
| (100 to 750) V | (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz | 0.04 % + 31 mV 0.04 % + 16 mV 0.06 % + 16 mV 0.12 % + 16 mV 0.3 % + 15 mV | |

| Parameter/Range | Frequency | Best Uncertainty ^{2,4,5} (±) | Comments |
|--|---|--|--|
| AC Voltage Flatness – Generate ³ | | | |
| 0.3 mV to 3.5 V | (10 to 30) Hz 30 Hz to 120 kHz | 0.27 % of reading 0.14 % of reading | Fluke 5720A or 5700A-03 (referenced to 1 kHz) |
| (0.3 to 1.1) mV | 120 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz | 0.46 % of reading 0.62 % of reading 0.80 % of reading 2.4 % of reading | |
| (0.3 to 3) mV | 120 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz | 0.22 % of reading 0.37 % of reading 0.55 % of reading 1.4 % of reading | |
| 3 mV to 3.5 V | 120 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz | 0.12 % of reading 0.21 % of reading 0.38 % of reading 0.86 % of reading | |
| AC Voltage Flatness – Measure ³ | | | |
| Up to 3 V | 10 Hz 100 Hz (10, 30) kHz 100 kHz 300 kHz 1 MHz 3 MHz 8 MHz 10 MHz 20 MHz 30 MHz 50 MHz 70 MHz 80 MHz 100 MHz | 0.02 % + 6.9 μV/V 80 μV + 5.5 μV/V 80 μV + 3.2 μV/V 0.01 % + 8.0 μV/V 0.01 % + 5.2 μV/V 0.01 % + 6.5 μV/V 0.13 % + 59 μV/V 0.13 % + 110 μV/V 0.13 % + 91 μV/V 0.25 % + 210 μV/V 0.25 % + 240 μV/V 0.61 % + 340 μV/V 0.9 % + 240 μV/V 1.1 % + 790 μV/V 1.3 % + 940 μV/V | By comparison to 11049A, 11050A, 11051A thermal voltage converters |

| Parameter/Range | Frequency | Best Uncertainty ^{2,4,5} (\pm) | Comments |
|---|---|---|---|
| Resistance – Generate ³ 0.1 Ω (1, 10) Ω 100 Ω (1, 10, 100) k Ω Shunt 15 A 0.1 Ω , 25 W Shunt 100A 0.01 Ω , 100 W Shunt 300A 0.01 Ω , 90 W Shunt 1000A 0.0001 Ω , 100 W | DC to 1 MHz, direct measurement Dissipated power: 0.3 Amps to full power $\leq 25W$ $\leq 25W$ $\leq 25W$ | 1 % of value 0.1 % of value 0.03 % of value 0.03 % of value 0.014 % 0.014 % 0.012 % 0.036 % | 16074A DUT box calibration R-L standard, BNC 3 terminal Guildline 9230-15 Guildline 9230-100 Guildline 9230-300 Guildline 9230-1000 Option 92310 Forced Air Cooling |
| Capacitance – Generate ³ Direct Measure (1, 10) pF (100, 1000) pF (0.01, 0.1, 1) μ F Algorithmic Derivation 1 pF (10, 100) pF | 1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz (1, 2) MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz | 0.01 % of reading 0.01 % of reading 0.01 % of reading 0.05 % of reading 0.06 % of reading 0.10 % of reading 0.2 % of reading 0.3 % of reading 1.0 % of reading 1.5 % of reading 0.025 % of reading 0.03 % of reading 0.04 % of reading 0.06 % of reading 0.15 % of reading 0.20 % of reading | 16380A/16380C standard air capacitor set, BNC 4 terminal pair |

| Parameter/Range | Frequency | Best Uncertainty ^{2,4,5} (±) | Comments |
|---|--|---|---|
| Capacitance Generate (cont) ³ – | | | |
| Algorithmic Derivation 1000 pF | 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz | 0.05 % of reading 0.06 % of reading 0.10 % of reading 0.15 % of reading 0.20 % of reading 0.50 % of reading 0.70 % of reading | 16380A/16380C standard air capacitor set, BNC 4 terminal pair |
| Substitution Method (0.01, 0.1, 1) μF | 120 Hz to 10 kHz | 0.025 % of reading 0.04 % of reading | |
| (0.01, 0.1) μF 1 μF | 100 kHz | 0.05 % of reading 0.1 % of reading | |
| Direct Measure 3.3 to 10.9999 nF 11 to 32.9999 nF 0.33 to 109.999 μF 110 to 329.999 μF 3.3 to 10.9999 μF | 10 to 1000 Hz 10 to 1000 Hz 10 to 600 Hz 10 to 300Hz 10 to 150Hz | 0.4 % of reading 0.4 % of reading 0.4 % of reading 0.4 % of reading 0.4 % of reading | Fluke 5720A |
| Voltage Ratio – Generate Decades ³ | | | |
| 1 and 2 All Other Decades | 1 kHz | 1.1 x 10 ⁻⁶ input 0.51 x 10 ⁻⁶ input | DT-72 ratio transformer |

| Parameter/Equipment | Range | Best Uncertainty ² (±) | Comments |
|---|---|---|------------|
| Electrical Calibration of Thermocouple Indicators ³ – | | | |
| Type J | (-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1200) °C | 0.36 °C 0.23 °C 0.21 °C 0.24 °C 0.32 °C | Fluke 5520 |

II. Electrical – RF/Microwave

| Parameter/Equipment/Range | Best Uncertainty ^{2, 11} (\pm) | Comments |
|--|---|--|
| <p>Amplitude Modulation – Measure^{3, 8}</p> <p>(0.15 to 10) MHz (5% to < 10%) AM (10% to 99%) AM</p> <p>(5% to < 10%) AM (10% to 99%) AM</p> <p>(10 to 1300) MHz (5% to <10%) AM (10% to 99%) AM</p> <p>(5% to <10%) AM (10% to 99%) AM</p> <p>1300 MHz to 26.5 GHz (5% to <10%) AM (10% to 99%) AM</p> <p>10 MHz to 26.5 GHz (5% to <10%) AM (10% to 99%) AM</p> | <p>$0.025AM + 0.030 \%$ $0.025AM + 0.14 \%$</p> <p>$0.038AM + 0.030 \%$ $0.038AM + 0.13 \%$</p> <p>$0.012AM + 0.033 \%$ $0.012AM + 0.17 \%$</p> <p>$0.038AM + 0.030 \%$ $0.037AM + 0.16 \%$</p> <p>$0.019AM + 0.029 \%$ $0.019AM + 0.14 \%$</p> <p>$0.038AM + 0.030 \%$ $0.038AM + 0.11 \%$</p> | <p>HP 8902 measuring receiver:</p> <p>rate: 50 Hz to 10 kHz, depth: 5% to 99%</p> <p>rate: 20 Hz to 10 kHz, depth: to 99%</p> <p>rate: 50 Hz to 10 kHz, depth: 5% to 99%</p> <p>rate: 20 Hz to 10 kHz, depth: to 99%</p> <p>rate: 50 Hz to 10 kHz, depth: 5% to 99%</p> <p>rate: 20 Hz to 10 kHz, depth: to 99%</p> |
| <p>Frequency Modulation – Measure^{3, 9}</p> <p>(0.25 to 10) MHz (0 to <4 k Hz Peak) FM ($\geq 4k$ to < 40k Hz Peak) FM</p> <p>(10 to 1300) MHz (0 to <4 k Hz Peak) FM ($\geq 4k$ to < 40k Hz Peak) FM ($\geq 40k$ to < 400k Hz Peak) FM</p> <p>(10 to 1300) MHz (0 to <4 k Hz Peak) FM ($\geq 4k$ to < 40k Hz Peak) FM ($\geq 40k$ to < 400k Hz Peak) FM</p> | <p>$0.024FM + 2.6 \text{ Hz Pk}$ $0.024FM + 10 \text{ Hz Pk}$</p> <p>$0.012FM + 2.6 \text{ Hz Pk}$ $0.012FM + 12 \text{ Hz Pk}$ $0.012FM + 110 \text{ Hz Pk}$</p> <p>$0.059FM + 2.8 \text{ Hz Pk}$ $0.059FM + 13 \text{ Hz Pk}$ $0.059FM + 110 \text{ Hz Pk}$</p> | <p>HP 8902 measuring receiver: 40.0 to 400.0: 1 digit = 100 Hz 4.00 to 39.99: 1 digit = 10 Hz 0 to 3.999: 1 digit = 1 Hz</p> <p>rate: 20 Hz to 10 kHz, ≤ 40 kHz peak</p> <p>rate: 50 Hz to 100 kHz, ≤ 400 kHz peak</p> <p>rate: 20 Hz to 200 kHz, ≤ 400 kHz peak</p> |

| Parameter/Equipment/Range | Best Uncertainty ^{2, 11} (\pm) | Comments |
|---|--|--|
| <p>Frequency Modulation – Measure (cont)^{3, 9}</p> <p>10 MHz to 26.5 GHz (10 to 1300) MHz (0 to <4 k Hz Peak) FM (\geq 4k to < 40k Hz Peak) FM (\geq 40k to < 400k Hz Peak) FM</p> <p>(>1.3 to 6.2) GHz (0 to <4 k Hz Peak) FM (\geq 4k to < 40k Hz Peak) FM (\geq 40k to < 400k Hz Peak) FM</p> <p>(>6.2 to 12.4) GHz (0 to <4 k Hz Peak) FM (\geq 4k to < 40k Hz Peak) FM (\geq 40k to < 400k Hz Peak) FM</p> <p>(>12.4 to 18.6) GHz (0 to <4 k Hz Peak) FM (\geq 4k to < 40k Hz Peak) FM (\geq 40k to < 400k Hz Peak) FM</p> <p>(>18.6 to 26.5) GHz (0 to <4 k Hz Peak) FM (\geq 4k to < 40k Hz Peak) FM (\geq 40k to < 400k Hz Peak) FM</p> <p>10 MHz to 26.5 GHz (10 to 1300) MHz (0 to <4 k Hz Peak) FM (\geq 4k to < 40k Hz Peak) FM (\geq 40k to < 400k Hz Peak) FM</p> <p>(>1.3 to 6.2) GHz (0 to <4 k Hz Peak) FM (\geq 4k to < 40k Hz Peak) FM (\geq 40k to < 400k Hz Peak) FM</p> <p>(>6.2 to 12.4) GHz (0 to <4 k Hz Peak) FM (\geq 4k to < 40k Hz Peak) FM (\geq 40k to < 400k Hz Peak) FM</p> <p>(>12.4 to 18.6) GHz (0 to <4 k Hz Peak) FM (\geq 4k to < 40k Hz Peak) FM (\geq 40k to < 400k Hz Peak) FM</p> | <p>0.012FM + 2.4 Hz Pk 0.012FM + 12.0 Hz Pk 0.012FM + 100 Hz Pk</p> <p>0.0099FM + 10 Hz Pk 0.012FM + 12 Hz Pk 0.012FM + 100 Hz Pk</p> <p>0.0075FM + 24 Hz Pk 0.012FM + 12 Hz Pk 0.012FM + 85 Hz Pk</p> <p>0.0049FM + 52 Hz Pk 0.011FM + 36 Hz Pk 0.012FM + 110 Hz Pk</p> <p>0.0035FM + 80 Hz Pk 0.011FM + 46 Hz Pk 0.012FM + 100 Hz Pk</p> <p>0.059FM + 2.8 Hz Pk 0.059FM + 14 Hz Pk 0.059FM + 120 Hz Pk</p> <p>0.058FM + 5.2 Hz Pk 0.059FM + 14 Hz Pk 0.059FM + 120 Hz Pk</p> <p>0.055FM + 15 Hz Pk 0.059FM + 14 Hz Pk 0.059FM + 120 Hz Pk</p> <p>0.050FM + 37 Hz Pk 0.059FM + 15 Hz Pk 0.059FM + 120 Hz Pk</p> | <p>HP 8902 measuring receiver: 11793A DownConverter, Gen. Ext L.O.</p> <p>rate: 50 Hz to 100 kHz, \leq400 kHz peak</p> <p>rate: 20 Hz to 200 kHz, \leq400 kHz peak</p> |

| Parameter/Equipment/Range | Best Uncertainty ^{2,11} (\pm) | Comments |
|---|---|---|
| Frequency Modulation – Measure (cont) ³ (>18.6 to 26.5) GHz (0 to <4 k Hz Peak) FM (\geq 4k to < 40k Hz Peak) FM (\geq 40k to < 400k Hz Peak) FM | 0.045FM + 62 Hz Pk 0.059FM + 16 Hz Pk 0.059FM + 120 Hz Pk | HP 8902 measuring receiver: 11793A DownConverter, Gen. Ext L.O. rate: 20 Hz to 200 kHz, \leq 400 kHz peak |

| Parameter/Range | Frequency | Best Uncertainty ² (\pm) | Comments |
|--|---------------------------------------|---|--|
| RF Absolute Power – Measure ^{3,6} | | | |
| 1 mW, Type-N(f), 50 Ω | 50 MHz | 0.015 dB (3.4 μ W) | HP 432A w/ HP 478A-H76 |
| (+20 to -30) dBm, 75 Ω | (100 to 600) kHz SWR \leq 1.8:1 | 0.057 dB | HP 436A or HP 438A w/ HP 8483A, Type-N(m) |
| | 600 kHz to 2 GHz SWR \leq 1.18:1 | 0.059 dB | |
| (+20 to -30) dBm, 50 Ω | (100 to 300) kHz SWR \leq 1.6:1 | 0.05 dB | HP 436A or HP 438A w/ HP 8482A, Type-N(m) |
| | 300 kHz to 1 MHz SWR \leq 1.2:1 | 0.049 dB | |
| | 1 MHz to 2 GHz SWR \leq 1.1:1 | 0.051 dB | |
| | (2 to 4.2) GHz SWR \leq 1.3:1 | 0.050 dB | |
| | | | |
| (-20 to -70) dBm, 50 Ω | (10 to 30) MHz SWR \leq 1.4:1 | 0.074 dB | HP 436A or HP 438A w/ HP 8481D, Type-N(m) |
| | 30 MHz to 4 GHz SWR \leq 1.15:1 | 0.074 dB | |
| | (4 to 10) GHz SWR \leq 1.21:1 | 0.077 dB | |
| | (10 to 15) GHz SWR \leq 1.3:1 | 0.10 dB | |
| | (15 to 18) GHz SWR \leq 1.35:1 | 0.11 dB | |

| Parameter/Range | Frequency | Best Uncertainty ² (±) | Comments | |
|---|------------------------------------|-----------------------------------|--|----------|
| RF Absolute Power – Measure (cont) ^{3, 6} | (+20 to -30) dBm, 50 Ω | (50 to 100) MHz SWR ≤ 1.15:1 | HP 436A or HP 438A w/ HP 8487A, 2.4 mm(m) | |
| | | (0.1 to 2) GHz SWR ≤ 1.1:1 | | 0.060 dB |
| | | (2 to 12.4) GHz SWR ≤ 1.15:1 | | 0.075 dB |
| | | (12.4 to 18) GHz SWR ≤ 1.2:1 | | 0.062 dB |
| | | (18 to 26.5) GHz SWR ≤ 1.25:1 | | 0.065 dB |
| | | (26.5 to 40) GHz SWR ≤ 1.4:1 | | 0.099 dB |
| | | (40 to 50) GHz SWR ≤ 1.5:1 | | 0.097 dB |
| | | | | 0.13 dB |
| | (-20 to -70) dBm, 50 Ω | (50 to 100) MHz SWR ≤ 1.19:1 | HP 436A or HP 438A w/ HP 8487D, 2.4 mm(m) | |
| | | (0.1 to 2) GHz SWR ≤ 1.15:1 | | 0.054 dB |
| | | (2 to 12.4) GHz SWR ≤ 1.2:1 | | 0.054 dB |
| | | (12.4 to 18) GHz SWR ≤ 1.29:1 | | 0.058 dB |
| | | (18 to 34) GHz SWR ≤ 1.37:1 | | 0.068 dB |
| | | (34 to 40) GHz SWR ≤ 1.61:1 | | 0.095 dB |
| (40 to 50) GHz SWR ≤ 1.86:1 | | 0.11 dB | | |
| (+30 to -20) dBm, 50 Ω | 100 kHz to 2.6 GHz SWR ≤ 1.15:1 | 0.19 dB | HP 8902A w/ HP 11722A, Type-N(m) | |
| (+30 to -20) dBm, 50 Ω | (50 to 1300) MHz SWR ≤ 1.15:1 | 0.071 dB | HP 8902A w/ HP 11792A, APC 3.5 mm(m) | |
| | (1.3 to 18) GHz SWR ≤ 1.25:1 | 0.071 dB | | |
| | (18 to 26.5) GHz SWR ≤ 1.4:1 | 0.081 dB | | |
| | | 0.092 dB | | |

| Parameter/Range | Frequency | Best Uncertainty ² (±) | Comments | |
|--|---------------------|-----------------------------------|---|---|
| Tuned RF Power ³ – Absolute – Measure ⁷ | | | | |
| ≤ +10 to ≥ -22 dBm | 2.5 MHz to 26.5 GHz | 0.17 dB | HP 8902A with HP 11722A or with HP 11792A and HP 11793A | |
| < -22 to ≥ -42 dBm | | 0.18 dB | | |
| < -42 to ≥ -50 dBm | | 0.20 dB | | |
| < -50 to ≥ -60 dBm | | 0.21 dB | | |
| < -60 to ≥ -72 dBm | | 0.22 dB | | |
| < -72 to ≥ -80 dBm | | 0.23 dB | | |
| < -80 to ≥ -92 dBm | | 0.24 dB | | |
| < -92 to ≥ -102 dBm | | 0.27 dB | | |
| < -102 to ≥ -110 dBm | | 0.28 dB | | |
| < -110 to ≥ -120 dBm | | 0.31 dB | | |
| < -110 to ≥ -120 dBm | | 0.34 dB | | |
| Relative – Measure | | | | |
| ≤ +10 to ≥ +2 dBm | 2.5 MHz to 26.5 GHz | 0.081 dB | | HP 8902A with HP 11722A or with HP 11792A and HP 11793A |
| < + 2 to ≥ -12 dBm | | 0.071 dB | | |
| < -12 to ≥ -22 dBm | | 0.081 dB | | |
| < -22 to ≥ -31 dBm | | 0.088 dB | | |
| < -31 to ≥ -40 dBm | | 0.095 dB | | |
| < -40 to ≥ -50 dBm | | 0.12 dB | | |
| < -50 to ≥ -61 dBm | | 0.15 dB | | |
| < -61 to ≥ -71 dBm | | 0.16 dB | | |
| < -71 to ≥ -80 dBm | | 0.17 dB | | |
| < -80 to ≥ -90 dBm | | 0.19 dB | | |
| < -90 to ≥ -100 dBm | | 0.22 dB | | |
| < -100 to ≥ -110 dBm | | 0.23 dB | | |
| < -110 to ≥ -120 dBm | | 0.27 dB | | |
| < -120 to ≥ -127 dBm | | 0.30 dB | | |

| Parameter/Range | Frequency | Best Uncertainty ² (±) | Comments |
|---|--|-----------------------------------|------------------------|
| RF Absolute Power – Generate ^{3,6} | | | |
| Into 50 Ω (10 to 3) V p-p | 0.001 Hz to 100 kHz SWR 1.2:1 | 0.12 dB | HP 3325A/B with BNC(f) |
| 2.99 V to 1 mV p-p | 0.001 Hz to 100 kHz SWR 1.2:1 | 0.23 dB | |
| Into 50 Ω (10 to 3) V p-p | 100 kHz to 20 MHz SWR ≤ 1.2:1 | 0.47 dB | HP 3325A/B with BNC(f) |
| 2.999 V to 1 mV p-p | 100 kHz to 10 MHz SWR ≤ 1.2:1 | 0.70 dB | |
| (2.999 to 0.1) V p-p | (10 to 20) MHz SWR ≤ 1.2:1 | 0.70 dB | |
| (99.99 to 1) mV p-p | (10 to 20) MHz SWR ≤ 1.2:1 | 1.0 dB | |
| Full Amplitude, 50Ω 13.01 dBm | 1 kHz to 25 MHz 200 Hz to 80 MHz | 0.14 dB 0.23 dB | HP 3325A/B with BNC(f) |
| Full Amplitude, 75Ω 11.25 dBm | 1 kHz to 25 MHz 200 Hz to 25 MHz | 0.14 dB 0.23 dB | |
| In 2 dB steps, 50 Ω (0 to -18) dBm (-20 to -58) dBm (-60 to -98) dBm | 200 Hz to 80 MHz 200 Hz to 80 MHz 200 Hz to 80 MHz | 0.28 dB 0.34 dB 0.47 dB | HP 3325A/B with BNC(f) |
| In 2 dB steps, 75 Ω (0 to -18) dBm | 200 Hz to 25 MHz (25 to 80) MHz | 0.28 dB 0.41 dB | |
| (-20 to -58) dBm | 200 Hz to 25 MHz (25 to 80) MHz | 0.34 dB 0.52 dB | |
| (-60 to -98) dBm | 200 Hz to 25 MHz (25 to 80) MHz | 0.47 dB 0.81 dB | |
| In 0.01 dB steps (0 to -1.99) dBm | 100 kHz to 2.56 GHz SWR ≤ 1.5:1 | 0.036 dB | HP 3335A with BNC(f) |

| Parameter/Range | Frequency | Best Uncertainty ² (±) | Comments |
|---|------------------------------------|-----------------------------------|----------------------|
| RF Absolute Power – Generate ^{3,6} – (cont) | | | |
| Into 50 Ω (+16 to -119.9) dBm | 100 kHz to 2.56 GHz SWR ≤ 1.5:1 | 1.2 dB | HP 8663A, Type-N(f) |
| (-120 to -129.9) dBm | 100 kHz to 2.56 GHz SWR ≤ 1.5:1 | 3.5 dB | HP 8663A, Type-N(f) |
| > +10 dBm | 10 MHz to 2 GHz SWR ≤ 1.6:1 | 1.4 dB | HP 83650B, 2.4 mm(m) |
| | (≥ 2 to ≤ 20) GHz SWR ≤ 1.6:1 | 1.5 dB | |
| > -10 dBm | 10 MHz to 2 GHz SWR ≤ 1.6:1 | 0.72 dB | HP 83650B, 2.4 mm(m) |
| | (≥ 2 to ≤ 20) GHz SWR ≤ 1.6:1 | 0.84 dB | |
| | (> 20 to ≤ 40) GHz SWR ≤ 1.8:1 | 1.1 dB | |
| | (> 40 to ≤ 50) GHz SWR ≤ 2:1 | 2.0 dB | |
| > -60 dBm | 10 MHz to 2 GHz SWR ≤ 1.6:1 | 1.1 dB | HP 83650B, 2.4 mm(m) |
| | (≥ 2 to ≤ 20) GHz SWR ≤ 1.6:1 | 1.2 dB | |
| | (> 20 to ≤ 40) GHz SWR ≤ 1.8:1 | 1.4 dB | |
| | (> 40 to ≤ 50) GHz SWR ≤ 2:1 | 2.4 dB | |
| ≤ -60 dBm | 10 MHz to 2 GHz SWR ≤ 1.6:1 | 1.7 dB | HP 83650B, 2.4 mm(m) |
| | (≥ 2 to ≤ 20) GHz SWR ≤ 1.6:1 | 1.8 dB | |
| | (> 20 to ≤ 40) GHz SWR ≤ 1.8:1 | 2.0 dB | |
| | (> 40 to ≤ 50) GHz SWR ≤ 2:1 | 3.0 dB | |

| Parameter/Range | Frequency | Best Uncertainty ² (±) | Comments |
|---|--|--|--|
| Power Sensor Calibration Factor ³ | 100 kHz to 50 GHz | 1 % of reading | Orion Test System |
| Thermal Noise Figure System – Measure ³ (0 to 30) dB | 10 MHz to 1.6 GHz SWR 1.7:1 ENR (14 to 16) dB | 0.25 dB | HP 8970A w/ HP 346C and APC-3.5 |
| Thermal Noise Measure ³ – ENR (14 to 16) dB | 10 MHz to 18 GHz SWR 1.25:1 (18 to 26.5) GHz SWR 1.35:1 | 0.12 dB 0.13 dB | HP 346C w/ APC-3.5 |
| Pulse – Generate ³ Transition Time Width RMS Jitter – Period, Delay and Width | 10 % to 90 % 150 ps to 10 ns 10 ns to < 100 ns ≥ 100 μs to < 10 ms ≥ 10 ms to < 100 ms ≥ 100 ms to < 0.99 ms 2 σ | 130 ps 130 ps (0.013 * Width) + 1.2 ns (0.013 * Width) + 140 ns (0.012 * Width) + 20 ns (0.012 * Width) + 190 ns 10 ps | HP 8133A HP 8133A HP 8161A HP 8161A HP 8161A HP 8161A HP 8133A |
| Pulse – Measure ³ RMS Jitter – Period, Delay and Width | 2 σ | 6.6 ps | HP 54124T; <i>D</i> is the instrument delay in 10 nano-seconds |

| Parameter/Range | Frequency | Best Uncertainty ² (±) | Comments |
|---|---------------------------------|-----------------------------------|-----------------------|
| Attenuation – Generate | | | |
| Coaxial, 1 dB Step ³ (0 to 11) dB | | | |
| 0 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.026 0.029 | HP 8494G w/ Type-N(f) |
| 1 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.026 0.029 | |
| 2 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.027 0.029 | |
| 3 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.028 0.029 | |
| 4 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.028 0.029 | |
| 5 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.029 0.029 | |
| 6 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.029 0.030 | |
| 7 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.030 0.030 | |
| 8 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.030 0.030 | |
| 9 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.031 0.030 | |
| 10 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.031 0.030 | |
| 11 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.031 0.030 | |

| Parameter/Range | Frequency | Best Uncertainty ² (±) | Comments |
|-----------------------------------|---------------------------------|-----------------------------------|-----------------------|
| Attenuation – Generate (cont.) | | | |
| Coaxial, 10 dB Step ³ | | | |
| 0 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.026 0.029 | HP 8496G w/ Type-N(f) |
| 10 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.031 0.030 | |
| 20 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.032 0.032 | |
| 30 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.034 0.035 | |
| 40 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.041 0.045 | |
| 50 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.052 0.054 | |
| 60 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.052 0.055 | |
| 70 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.054 0.057 | |
| 80 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.059 0.064 | |
| 90 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.066 0.071 | |
| 100 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.067 0.071 | |
| 110 dB | 50 MHz to 2 GHz (2 to 4) GHz | 0.074 0.073 | |

| Parameter/Range | Frequency | Best Uncertainty ² (±) | Comments |
|-----------------------------------|-------------------------------|-----------------------------------|-------------------|
| Attenuation – Generate (cont.) | | | |
| Coaxial, Fixed ³ | | | |
| 3 dB | DC to 2 GHz, SWR < 1.25:1 | 0.028 | HP 8491A/B Type-N |
| | (2 to 4) GHz, SWR < 1.2:1 | 0.029 | |
| | (4 to 18) GHz, SWR < 1.2:1 | 0.053 | |
| 6 dB | DC to 2 GHz, SWR < 1.25:1 | 0.029 | |
| | (2 to 4) GHz, SWR < 1.2:1 | 0.030 | |
| | (4 to 18) GHz, SWR < 1.2:1 | 0.053 | |
| 10 dB | DC to 2 GHz, SWR < 1.25:1 | 0.031 | |
| | (2 to 4) GHz, SWR < 1.2:1 | 0.030 | |
| | (4 to 18) GHz, SWR < 1.2:1 | 0.053 | |
| 20 dB | DC to 2 GHz, SWR < 1.5:1 | 0.032 | |
| | (2 to 4) GHz, SWR < 1.5:1 | 0.032 | |
| | (4 to 18) GHz, SWR < 1.5:1 | 0.052 | |

| Parameter/Range | Best Uncertainty ² (±) | Comments |
|---|---|--|
| Reflection S ₁₁ / S ₂₂ – Measure ³ | | |
| 5 Hz to 200 MHz (0 to 1.0) lin | (± 0.004 to ± 0.020) lin (± 180 to ± 2.3) deg | 50 Ohm Network Analyzer HP3577A S Parameter 35677A/87512A-S-11 Type-N Precision Cal Kit HP85032B |
| 100 kHz to 200 MHz (0 to 1.0) lin | (± 0.0059 to ± 0.021) lin (± 180 to ± 2.6) deg | 75 Ohm Network Analyzer HP3577A S Parameter 35677A Min Loss Pad 11852B Type-N Precision Cal Kit 85036B |
| 300 kHz to 1.3 GHz (0 to 1.0) lin | (± 0.0044 to ± 0.022) lin (± 180 to ± 1.3) deg | 75 Ohm Network Analyzer 8753L S Parameter 85047A Min Loss Pad 11852B Type-N Precision Cal Kit 85036B |
| 300 kHz to 1.3 GHz (0 to 1.0) lin | (± 0.0071 to ± 0.035) lin (± 180 to ± 2.0) deg | 75 Ohm Network Analyzer 8753L S Parameter 85047A Min Loss Pad 11852B Type-N Precision Cal Kit 85036B |
| 300 kHz to 1.3 GHz (0 to 1.0) lin | (± 0.0038 to ± 0.017) lin (± 180 to ± 0.96) deg | Network Analyzer HP8753ES Type-N Precision Cal Kit 85032B |
| 1.3 GHz to 3 GHz (0 to 1.0) lin | (± 0.0051 to ± 0.026) lin (± 180 to ± 1.504) deg | |
| 3 GHz to 6 GHz (0 to 1.0) lin | (± 0.011 to ± 0.050) lin (± 180 to ± 3.0) deg | |
| 300 kHz to 1.3 GHz (0 to 1.0) lin | (± 0.0019 to ± 0.0072) lin (± 180 to ± 0.42) deg | Network Analyzer HP8753ES APC 7mm Precision Cal Kit HP85031B |
| 1.3 GHz to 3 GHz (0 to 1.0) lin | (± 0.0036 to ± 0.011) lin (± 180 to ± 0.59) deg | |
| 3 GHz to 6 GHz (0 to 1.0) lin | (± 0.0057 to ± 0.018) lin (± 180 to ± 1.1) deg | |
| 45 MHz to 2 GHz (0 to 1) lin | (± 0.0010 to ± 0.0020) lin | Network Analyzer: HP8510B/C S Parameter: HP8515A Source: HP83631A/B Cable: HP85132C 7 mm Precision Cal Kit ET33733 |
| (0 to 0.01) lin | (± 180 to ± 6.0) deg | |
| (0.01 to 0.1) lin | (± 6.0 to ± 0.71) deg | |
| (0.1 to 0.5) lin | (± 0.71 to ± 0.27) deg | |
| (0.5 to 1.0) lin | (± 0.27 to ± 0.20) deg | |

| Parameter/Range | Best Uncertainty ² (±) | Comments | |
|---|-----------------------------------|---|--|
| Reflection S ₁₁ / S ₂₂ – Measure ³ | | | |
| (2 to 8) GHz (0 to 1) lin | (± 0.0011 to ± 0.0023) lin | Network Analyzer: HP8510B/C S Parameter: HP8515A Source: HP83631A/B Cable: HP85132C 7 mm Precision Cal Kit ET33733 | |
| (0 to 0.01) lin | (± 180 to ± 6.7) deg | | |
| (0.01 to 0.1) lin | (± 6.7 to ± 0.84) deg | | |
| (0.1 to 0.5) lin | (± 0.84 to ± 0.34) deg | | |
| (0.5 to 1.0) lin | (± 0.34 to ± 0.30) deg | | |
| (8 to 18) GHz (0 to 1) lin | (± 0.0016 to ± 0.0034) lin | | |
| (0 to 0.01) lin | (± 180 to ± 9.6) deg | | |
| (0.01 to 0.1) lin | (± 9.6 to ± 1.3) deg | | |
| (0.1 to 0.5) lin | (± 1.3 to ± 0.52) deg | | |
| (0.5 to 1.0) lin | (± 0.52 to ± 0.47) deg | | |
| 45 MHz to 2 GHz (0 to 1) lin | (± 0.0014 to ± 0.0024) lin | | Network Analyzer: HP8510B/C S Parameter: HP8515A Source: HP83631A/B Cable HP85132C N-Precision Cal Kit ET33717 |
| (0 to 0.01) lin | (± 180 to ± 8.4) deg | | |
| (0.01 to 0.1) lin | (± 8.4 to ± 0.94) deg | | |
| (0.1 to 0.5) lin | (± 0.94 to ± 0.31) deg | | |
| (0.5 to 1.0) lin | (± 0.31 to ± 0.22) deg | | |
| (2 to 8) GHz (0 to 1) lin | (± 0.0018 to ± 0.0040) lin | | |
| (0 to 0.01) lin | (± 180 to ± 11) deg | | |
| (0.01 to 0.1) lin | (± 11 to ± 1.3) deg | | |
| (0.1 to 0.5) lin | (± 1.3 to ± 0.43) deg | | |
| (0.5 to 1.0) lin | (± 0.43 to ± 0.41) deg | | |
| (8 to 18) GHz (0 to 1) lin | (± 0.0028 to ± 0.0089) lin | | |
| (0 to 0.01) lin | (± 180 to ± 17) deg | | |
| (0.01 to 0.1) lin | (± 17 to ± 1.9) deg | | |
| (0.1 to 0.5) lin | (± 1.9 to ± 0.70) deg | | |
| (0.5 to 1.0) lin | (± 0.70 to ± 0.79) deg | | |
| 45 MHz to 2 GHz (0 to 1) lin | (± 0.0022 to ± 0.0035) lin | Network Analyzer: HP8510B/C S Parameter: HP8515A Source: HP83631A/B Cable: HP85131A/C 3.5mm Precision Cal Kit ET33700 | |
| (0 to 0.01) lin | (± 180 to ± 14) deg | | |
| (0.01 to 0.1) lin | (± 14 to ± 1.4) deg | | |
| (0.1 to 0.5) lin | (± 1.4 to ± 0.39) deg | | |
| (0.5 to 1.0) lin | (± 0.39 to ± 0.29) deg | | |

| Parameter/Range | Best Uncertainty ² (±) | Comments |
|--|-----------------------------------|---|
| Reflection S ₁₁ / S ₂₂ – Measure (cont) ³ | | |
| (2 to 8) GHz (0 to 1) lin | (± 0.0029 to ± 0.0044) lin | Network Analyzer: HP8510B/C S Parameter: HP8515A Source: HP83631A/B Cable: HP85131A/C 3.5mm Precision Cal Kit ET33700 |
| (0 to 0.01) lin | (± 180 to ± 17) deg | |
| (0.01 to 0.1) lin | (± 17 to ± 1.9) deg | |
| (0.1 to 0.5) lin | (± 1.9 to ± 0.54) deg | |
| (0.5 to 1.0) lin | (± 0.54 to ± 0.43) deg | |
| (8 to 18) GHz (0 to 1) lin | (± 0.0032 to ± 0.0054) lin | |
| (0 to 0.01) lin | (± 180 to ± 20) deg | |
| (0.01 to 0.1) lin | (± 20 to ± 2.2) deg | |
| (0.1 to 0.5) lin | (± 2.2 to ± 0.72) deg | |
| (0.5 to 1.0) lin | (± 0.72 to ± 0.61) deg | |
| (20 to 26.5) GHz (0 to 1) lin | (± 0.0038 to ± 0.0069) lin | |
| (0 to 0.01) lin | (± 180 to ± 23) deg | |
| (0.01 to 0.1) lin | (± 23 to ± 2.6) deg | |
| (0.1 to 0.5) lin | (± 2.6 to ± 0.88) deg | |
| (0.5 to 1.0) lin | (± 0.88 to ± 0.76) deg | |
| 45 MHz to 2 GHz (0 to 1) lin | (± 0.0080 to ± 0.0118) lin | Network Analyzer: HP8510B/C S Parameter: HP8517A Source: HP83651A/B Cable: HP85133E 2.4mm Precision Cal Kit HP85056A |
| (0 to 0.01) lin | (± 180 to ± 54) deg | |
| (0.01 to 0.1) lin | (± 54 to ± 4.8) deg | |
| (0.1 to 0.5) lin | (± 4.8 to ± 1.1) deg | |
| (0.5 to 1.0) lin | (± 1.1 to ± 0.81) deg | |
| (2 to 20) GHz (0 to 1) lin | (± 0.0080 to ± 0.016) lin | |
| (0 to 0.01) lin | (± 180 to ± 54) deg | |
| (0.01 to 0.1) lin | (± 54 to ± 5.1) deg | |
| (0.1 to 0.5) lin | (± 5.1 to ± 1.4) deg | |
| (0.5 to 1.0) lin | (± 1.4 to ± 1.3) deg | |
| (20 to 40) GHz (0 to 1) lin | (± 0.013 to ± 0.026) lin | |
| (0 to 0.01) lin | (± 180 to ± 180) deg | |
| (0.01 to 0.1) lin | (± 180 to ± 8.0) deg | |
| (0.1 to 0.5) lin | (± 8.0 to ± 2.3) deg | |
| (0.5 to 1.0) lin | (± 2.3 to ± 2.2) deg | |

| Parameter/Range | Best Uncertainty ² (±) | Comments |
|---|--|---|
| Reflection S_{11}/ S_{22} – Measure (cont) ³ (40 to 50) GHz (0 to 1) lin (0 to 0.01) lin (0.01 to 0.1) lin (0.1 to 0.5) lin (0.5 to 1.0) lin | (± 0.017 to ± 0.033) lin (± 180 to ± 180) deg (± 180 to ± 11) deg (± 11 to ± 2.9) deg (± 2.9 to ± 2.7) deg | Network Analyzer: HP8510B/C S Parameter: HP8517A Source: HP83651A/B Cable: HP85133E 2.4mm Precision Cal Kit HP85056A |
| Transmission S_{12}/ S_{21} – Measure ³ 5 Hz to 200 MHz (0 to 20) dB (20 to 40) dB (40 to 60) dB 300 kHz to 1.3 GHz (0 to 20) dB (20 to 40) dB (40 to 60) dB 1.3 GHz to 3 GHz (0 to 20) dB (20 to 40) dB (40 to 60) dB | (± 0.055 to ± 0.055) dB (± 1.1 to ± 1.1) deg (± 0.055 to ± 0.056) dB (± 1.1 to ± 1.2) deg (± 0.056 to ± 0.19) dB (± 1.2 to ± 3.0) deg (± 0.041 to ± 0.063) dB (± 0.42 to ± 0.46) deg (± 0.063 to ± 0.088) dB (± 0.46 to ± 0.62) deg (± 0.088 to ± 0.29) dB (± 0.62 to ± 2.0) deg (± 0.056 to ± 0.076) dB (± 0.79 to ± 1.3) deg (± 0.076 to ± 0.11) dB (± 1.3 to ± 1.4) deg (± 0.11 to ± 0.32) dB (± 1.4 to ± 2.2) deg | 50 Ohm Network Analyzer HP3577A Transmission/Reflection Test Set 3566A/87512A Type-N Precision Cal Kit 85032B 50 Ohm Network Analyzer 8753ES Type-N Precision Cal Kit 85032B |

| Parameter/Range | Best Uncertainty ² (±) | Comments |
|---|---|--|
| Transmission S ₁₂ / S ₂₁ – Measure (cont) | | |
| 3 GHz to 6 GHz (0 to 20) dB | (± 0.094 to ± 0.13) dB (± 1.2 to ± 1.6) deg | 50 Ohm Network Analyzer 8753ES Type-N Precision Cal Kit 85032B |
| (20 to 40) dB | (± 0.13 to ± 0.16) dB (± 1.6 to ± 1.7) deg | |
| (40 to 60) dB | (± 0.16 to ± 0.51) dB (± 1.7 to ± 3.6) deg | |
| 100 kHz to 200 MHz (0 to 20) dB | (± 0.061 to ± 0.056) dB (± 1.1 to ± 1.1) deg | 75 Ohm Network Analyzer 3577A Transmission/Reflection Test Set 35677A Type-N Precision Cal Kit 85036B |
| (20 to 40) dB | (± 0.056 to ± 0.061) dB (± 1.1 to ± 1.3) deg | |
| (40 to 60) dB | (± 0.061 to ± 0.28) dB (± 1.3 to ± 4.5) deg | |
| 300 kHz to 1.3 GHz (0 to 20) dB | (± 0.072 to ± 0.093) dB (± 0.48 to ± 0.83) deg | 75 Ohm Network Analyzer 8753ES Transmission/Reflection Test Set 35677A Type-N Precision Cal Kit 85036B |
| (20 to 40) dB | (± 0.093 to ± 0.095) dB (± 0.83 to ± 0.85) deg | |
| (40 to 60) dB | (± 0.095 to ± 0.20) dB (± 0.85 to ± 1.5) deg | |
| 300 kHz to 1.3 GHz (0 to 20) dB | (± 0.091 to ± 0.12) dB (± 0.63 to ± 0.95) deg | |
| (20 to 40) dB | (± 0.12 to ± 0.12) dB (± 0.947 to ± 1.468) deg | |
| (40 to 60) dB | (± 0.13 to ± 0.22) dB (± 1.5 to ± 1.7) deg | |
| 300 kHz to 1.3 GHz (0 to 20) dB | (± 0.028 to ± 0.049) dB (± 0.30 to ± 0.41) deg | Network Analyzer HP8753ES APC 7mm Precision Cal Kit HP85031B |
| (20 to 40) dB | (± 0.049 to ± 0.075) dB (± 0.41 to ± 0.56) deg | |
| (40 to 60) dB | (± 0.075 to ± 0.28) dB (± 0.56 to ± 1.9) deg | |

| Parameter/Range | Best Uncertainty ² (±) | Comments |
|--|---|--|
| Transmission S12/ S21 – Measure (cont.) ³ | | |
| 100 kHz to 200 MHz (0 to 20) dB | (± 0.061 to ± 0.056) dB (± 1.1 to ± 1.1) deg | 75 Ohm Network Analyzer 3577A Transmission/Reflection Test Set 35677A Type-N Precision Cal Kit 85036B |
| (20 to 40) dB | (± 0.056 to ± 0.061) dB (± 1.1 to ± 1.3) deg | |
| (40 to 60) dB | (± 0.061 to ± 0.28) dB (± 1.3 to ± 4.5) deg | |
| 300 kHz to 1.3 GHz (0 to 20) dB | (± 0.072 to ± 0.093) dB (± 0.48 to ± 0.83) deg | 75 Ohm Network Analyzer 8753ES Transmission/Reflection Test Set 35677A Type-N Precision Cal Kit 85036B |
| (20 to 40) dB | (± 0.093 to ± 0.095) dB (± 0.83 to ± 0.85) deg | |
| (40 to 60) dB | (± 0.095 to ± 0.20) dB (± 0.85 to ± 1.5) deg | |
| 300 kHz to 1.3 GHz (0 to 20) dB | (± 0.091 to ± 0.12) dB (± 0.63 to ± 0.95) deg | |
| (20 to 40) dB | (± 0.12 to ± 0.12) dB (± 0.947 to ± 1.468) deg | |
| (40 to 60) dB | (± 0.13 to ± 0.22) dB (± 1.5 to ± 1.7) deg | |
| 300 kHz to 1.3 GHz (0 to 20) dB | (± 0.028 to ± 0.049) dB (± 0.30 to ± 0.41) deg | Network Analyzer HP8753ES APC 7mm Precision Cal Kit HP85031B |
| (20 to 40) dB | (± 0.049 to ± 0.075) dB (± 0.41 to ± 0.56) deg | |
| (40 to 60) dB | (± 0.075 to ± 0.28) dB (± 0.56 to ± 1.9) deg | |

| Parameter/Range | Best Uncertainty ² (±) | Comments |
|--|---|--|
| Transmission S ₁₂ / S ₂₁ – Measure (cont.) ³ | | |
| 1.3 GHz to 3 GHz (0 to 20) dB | (± 0.033 to ± 0.055) dB (± 0.37 to ± 0.47) deg | Network Analyzer HP8753ES APC 7mm Precision Cal Kit HP85031B |
| (20 to 40) dB | (± 0.055 to ± 0.081) dB (± 0.47 to ± 0.60) deg | |
| (40 to 60) dB | (± 0.081 to ± 0.32) dB (± 0.60 to ± 2.2) deg | |
| 3 GHz to 6 GHz (0 to 20) dB | (± 0.047 to ± 0.069) dB (± 1.4 to ± 1.2) deg | |
| (20 to 40) dB | (± 0.069 to ± 0.11) dB (± 1.2 to ± 1.3) deg | |
| (40 to 60) dB | (± 0.11 to ± 0.49) dB (± 1.3 to ± 3.4) deg | |
| 45 MHz to 2 GHz (0 to 20) dB | (± 0.012 to ± 0.023) dB (± 0.15 to ± 0.24) deg | Network Analyzer HP8510B/C S Parameter HP8515A Source HP83631A/B Cable HP 85132C 7mm Precision Cal Kit ET33733 |
| (20 to 40) dB | (± 0.023 to ± 0.034) dB (± 0.237 to ± 0.315) deg | |
| (40 to 60) dB | (± 0.034 to ± 0.21) dB (± 0.32 to ± 1.5) deg | |
| (2 to 8) GHz (0 to 20) dB | (± 0.013 to ± 0.018) dB (± 1.1 to ± 1.1) deg | |
| (20 to 40) dB | (± 0.018 to ± 0.036) dB (± 1.1 to ± 1.3) deg | |
| (40 to 60) dB | (± 0.036 to ± 0.29) dB (± 1.3 to ± 2.9) deg | |

| Parameter/Range | Best Uncertainty ² (±) | Comments |
|--|---|--|
| Transmission S ₁₂ / S ₂₁ – Measure (cont) ³ | | |
| (8 to 18) GHz (0 to 20) dB | (± 0.014 to ± 0.018) dB (± 2.2 to ± 2.2) deg | Network Analyzer HP8510B/C S Parameter HP8515A Source HP83631A/B Cable HP 85132C 7mm Precision Cal Kit ET33733 |
| (20 to 40) dB | (± 0.018 to ± 0.050) dB (± 2.2 to ± 2.4) deg | |
| (40 to 60) dB | (± 0.050 to ± 0.42) dB (± 2.4 to ± 4.8) deg | |
| 45 MHz to 2 GHz (0 to 20) dB | (± 0.012 to ± 0.023) dB (± 0.15 to ± 0.24) deg | Network Analyzer HP8510B/C S Parameter HP8515A Source HP83631A/B Cable HP 85132C N-Precision Cal Kit ET33717 |
| (20 to 40) dB | (± 0.023 to ± 0.034) dB (± 0.24 to ± 0.32) deg | |
| (40 to 60) dB | (± 0.034 to ± 0.21) dB (± 0.32 to ± 1.5) deg | |
| (2 to 8) GHz (0 to 20) dB | (± 0.013 to ± 0.019) dB (± 1.1 to ± 1.1) deg | |
| (20 to 40) dB | (± 0.019 to ± 0.036) dB (± 1.1 to ± 1.3) deg | |
| (40 to 60) dB | (± 0.036 to ± 0.29) dB (± 1.3 to ± 2.9) deg | |
| (8 to 18) GHz (0 to 20) dB | (± 0.020 to ± 0.023) dB (± 2.2 to ± 2.3) deg | |
| (20 to 40) dB | (± 0.023 to ± 0.052) dB (± 2.3 to ± 2.5) deg | |
| (40 to 60) dB | (± 0.052 to ± 0.42) dB (± 2.4 to ± 4.8) deg | |

| Parameter/Equipment/Range | Best Uncertainty ² (±) | Comments |
|--|---|--|
| Transmission S ₁₂ / S ₂₁ – Measure (cont) ³ | | |
| 45 MHz to 2 GHz (0 to 20) dB | (± 0.013 to ± 0.023) dB (± 0.15 to ± 0.24) deg | Network Analyzer HP8510B/C S Parameter HP8515A Source HP83631A/B Cable HP 85131A/C 3.5mm Precision Cal Kit ET33700 |
| (20 to 40) dB | (± 0.023 to ± 0.034) dB (± 0.24 to ± 0.32) deg | |
| (40 to 60) dB | (± 0.034 to ± 0.21) dB (± 0.32 to ± 1.5) deg | |
| (2 to 8) GHz (0 to 20) dB | (± 0.013 to ± 0.019) dB (± 1.1 to ± 1.1) deg | |
| (20 to 40) dB | (± 0.019 to ± 0.036) dB (± 1.1 to ± 1.3) deg | |
| (40 to 60) dB | (± 0.036 to ± 0.29) dB (± 1.3 to ± 2.9) deg | |
| (8 to 20) GHz (0 to 20) dB | (± 0.016 to ± 0.020) dB (± 2.4 to ± 2.5) deg | |
| (20 to 40) dB | (± 0.020 to ± 0.052) dB (± 2.5 to ± 2.7) deg | |
| (40 to 60) dB | (± 0.052 to ± 0.44) dB (± 2.7 to ± 5.1) deg | |
| (20 to 26.5) GHz (0 to 20) dB | (± 0.021 to ± 0.028) dB (± 3.2 to ± 3.2) deg | |
| (20 to 40) dB | (± 0.028 to ± 0.16) dB (± 3.2 to ± 4.1) deg | |
| (40 to 60) dB | (± 0.16 to ± 1.7) dB (± 4.1 to ± 14) deg | |

| Parameter/Range | Best Uncertainty ² (±) | Comments |
|--|---|--|
| Transmission S_{12}/S_{21} – Measure (cont) ³ | | |
| 45 MHz to 2 GHz (0 to 20) dB | (± 0.022 to ± 0.027) dB (± 0.24 to ± 0.29) deg | Network Analyzer HP8510B/C S Parameter HP8517A Source HP83651A/B Cable HP 85133E 2.4mm Precision Cal Kit HP85056A |
| (20 to 40) dB | (± 0.027 to ± 0.13) dB (± 0.29 to ± 0.92) deg | |
| (40 to 60) dB | (± 0.13 to ± 1.3) dB (± 0.92 to ± 7.8) deg | |
| (2 to 20) GHz (0 to 20) dB | (± 0.049 to ± 0.050) dB (± 2.3 to ± 2.4) deg | |
| (20 to 40) dB | (± 0.050 to ± 0.057) dB (± 2.4 to ± 2.4) deg | |
| (40 to 60) dB | (± 0.057 to ± 0.25) dB (± 2.4 to ± 3.6) deg | |
| (20 to 40) GHz (0 to 20) dB | (± 0.12 to ± 0.12) dB (± 4.6 to ± 4.6) deg | |
| (20 to 40) dB | (± 0.12 to ± 0.23) dB (± 4.6 to ± 5.4) deg | |
| (40 to 60) dB | (± 0.23 to ± 2.2) dB (± 5.4 to ± 17) deg | |
| (40 to 50) GHz (0 to 20) dB | (± 0.15 to ± 0.17) dB (± 5.3 to ± 5.9) deg | |
| (20 to 40) dB | (± 0.17 to ± 0.80) dB (± 5.9 to ± 9.8) deg | |
| (40 to 60) dB | (± 0.80 to ± 17) dB (± 9.8 to ± 64) deg | |

III. Time and Frequency

| Parameter/Equipment | Range | Best Uncertainty ^{2, 11} (\pm) | Comments |
|--------------------------------------|--|---|---|
| Time Interval – Measure ³ | 60 ps to 1 μ s 60 ps to 700 ps >700 ps to 1.4 ns >1.4 ns to 4.4 ns >4.4 ns to 9.0 ns >9.0 ns to 18 ns >18 ns to 44 ns >44 ns to 88 ns >88 ns to 180 ns >180 ns to 440 ns >440 ns to 880 ns >880 ns to 1.0 μ s | 12 ps 13 ps $1.4 \times 10^{-3} TI + 13$ ps $1.1 \times 10^{-3} TI + 17$ ps $9.5 \times 10^{-4} TI + 26$ ps $8.0 \times 10^{-4} TI + 56$ ps $7.6 \times 10^{-4} TI + 110$ ps $7.2 \times 10^{-4} TI + 210$ ps $6.8 \times 10^{-4} TI + 540$ ps $7.0 \times 10^{-4} TI + 1000$ ps $5.4 \times 10^{-4} TI + 2.3$ ns | HP 54124T, includes transition time; Δt is the time interval in seconds. |
| | 10 ns to 10s | 2.9 ns | HP 5334B/HP 5071A cesium beam standard |
| Frequency – Generate ³ | 5 MHz, 10 MHz | 10 pHz/Hz | HP 5071A cesium beam frequency standard, 2-1/2 day average, GPS disciplined, Datum 8040 |
| Frequency – Measure ³ | 1 Hz to 40 GHz | 50 pHz/Hz | HP 53132A HP 5352B |

IV. Optical Quantities

| Parameter/Equipment | Range | Best Uncertainty ² (\pm) | Comments |
|--|----------------------|---|--------------------------|
| Laser Optical Power – Measure ³ | (80 to 1000) μ W | 8 μ W | UDT Instruments S370/247 |
| Wavelength – Measure ³ | 633 nm | 4.1×10^{-6} nm | HP 5517B/5508A |

V. Thermodynamics

| Parameter/Equipment | Range | Best Uncertainty ² (±) | Comments |
|------------------------------------|----------------|-----------------------------------|-----------------------|
| Temperature – Measure ³ | -1 °C to 41 °C | 0.04 °C | HP 2804A w/ HP 18111A |

Standards Laboratory

VI. Electrical – RF/Microwave ¹⁰

| Parameter/Equipment | Range/Frequency | Best Uncertainty ² (±) | Comments |
|---------------------------------------|---|--|--|
| RF Power Sensor – Calibration Factors | | | |
| Coaxial Thermocouple Power Sensors | (0.1 to 100) MHz (0.1 to 18) GHz (18 to 26.5) GHz (26.5 to 40) GHz (40 to 50) GHz | 0.6 % of reading 1.0 % of reading 1.5 % of reading 1.9 % of reading 3.2 % of reading | Calibrated at 1 mW input power, referenced to 50 MHz at 1 mW |
| | (0.1 to 100) MHz (0.1 to 3) GHz | 0.8 % of reading 1.1 % of reading | 75 Ω 75 Ω |
| Waveguide Thermocouple Power Sensors | (26.5 to 40) GHz (33 to 50) GHz | 1.5 % of reading 3.0 % of reading | Calibrated at 1 mW input power, referenced to 50 MHz at 1 mW |
| Coaxial Diode Power Sensors | (0.1 to 100) MHz (0.1 to 18) GHz (18 to 26.5) GHz (26.5 to 40) GHz (40 to 50) GHz | 1.4 % of reading 1.6 % of reading 2.1 % of reading 2.3% of reading 3.3 % of reading | Calibrated at 1 mW input power, referenced to 50 MHz at 1 mW |
| Waveguide Diode Power Sensors | (26.5 to 40) GHz (33 to 50) GHz | 1.6 % of reading 3.2 % of reading | Calibrated at 1 mW input power, referenced to 50 MHz at 1 mW |
| Coaxial Thermistor Power Sensors | (0.1 to 10) MHz (10 to 100) MHz (0.1 to 18) GHz 50 MHz | 0.5 % of reading 0.6 % of reading 1.2 % of reading 0.35 % of reading | Calibrated at 1 mW input power |
| Waveguide Thermistor Power Sensors | (2.6 to 40) GHz (33 to 50) GHz | 1.3 % of reading 1.5 % of reading | Calibrated at 1 mW input power: S/X/M/P/K/R bands, Q band |

| Parameter/Equipment | Range/Frequency | Best Uncertainty ² (±) | Comments | |
|---|---------------------------------|-----------------------------------|--|---|
| Noise Measure – Calibration of Noise Sources and Noise Figure Meters against Reference Noise Sources, (5 to 17) dB | With Coaxial Noise Sources | 10 MHz to 18 GHz | 0.12 dB | Uncertainties for 2.4 mm can be 0.05 dB higher |
| | | (18 to 26.5) GHz | 0.13 dB | 2.4 mm and 3.5 mm output port |
| | | (26.5 to 40) GHz | 0.17 dB | 2.4 mm output port |
| | | (40 to 50) GHz | 0.20 dB | 2.4 mm output port |
| | With Waveguide Noise Sources | (8.2 to 12.4) GHz | 0.14 dB | WR-90 |
| | | (10 to 15) GHz | 0.13 dB | WR-75 |
| | | (12.4 to 18) GHz | 0.13 dB | WR-62 |
| | | (18 to 26.5) GHz | 0.12 dB | WR-42 |
| | | (26.5 to 40) GHz | 0.15 dB | WR-28 |
| | | (33 to 50) GHz | 0.21 dB | WR-22 |
| Attenuation – Measure | | | | |
| Coaxial Attenuators, 1 dB steps (0 to 12) dB | 1.0 kHz | 0.008 dB | HP measurement system utilizing parallel IF method | |
| | 50 kHz to 2 GHz | 0.008 dB | | |

| Parameter/Equipment | Range/Frequency | Best Uncertainty ² (±) | Comments |
|---|-----------------|--|--|
| Attenuation – Measure (cont) | | | |
| Coaxial Attenuators, 10 dB steps (0 to 70) dB | 1 kHz to 50 MHz | 0.003 dB + 0.003 dB per 10 dB step | HP measurement system utilizing parallel IF method |
| | 50 MHz to 1 GHz | 0.003 dB + 0.003 dB per 10 dB step | |
| | (1 to 2) GHz | 0.004 dB + 0.004 dB per 10 dB step | |
| (80 to 120) dB | 1 kHz to 50 MHz | $U + 0.006$ dB per 10 dB step above 70 dB | $(U =$ uncertainty at 70 dB) |
| | 50 MHz to 1 GHz | $U + 0.009$ dB per 10 dB step above 70 dB | |
| | (1 to 2) GHz | $U + 0.012$ dB per 10 dB step above 70 dB | |

VII. Mechanical

| Parameter/Equipment | Range | Best Uncertainty ² (±) | Comments |
|---------------------|-----------------------|-----------------------------------|----------|
| Torque | 8 in-lbf 12 in-lbf | 0.093 in-lbf 0.13 in-lbf | BMX-50i |

¹ This laboratory offers commercial calibration service and field calibration service.

² “Best Uncertainty” is the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards of nearly ideal measuring equipment. Best uncertainties represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of $k = 2$. The best uncertainty of a specific calibration performed by the laboratory may be greater than the best uncertainty due to the behavior of the customer’s device and to influences from the circumstances of the specific calibration.

³ Field calibration service is available for this calibration and this laboratory meets A2LA R104 – *General Requirements: Accreditation of Field Testing and Field Calibration Laboratories* for these calibrations. Please note the uncertainties achievable on a customer's site can normally be expected to be larger than the Best Measurement Capabilities (BMC) that the accredited laboratory has been assigned as Best Uncertainty on the A2LA Scope. Allowance must be made for aspects such as the environment at the place of calibration and for other possible adverse effects such as those caused by transportation of the calibration equipment. The usual allowance for the uncertainty introduced by the item being calibrated, (e.g. resolution) must also be considered and this, on its own, could result in the calibration uncertainty being larger than the BMC.

⁴ Based on using the standard at the temperature the Fluke 5720A/5725A was calibrated ($t_{cal} \pm 5 \text{ }^\circ\text{C}$) and assuming the instrument is zeroed at least every seven days or when the ambient temperature changes more than $5 \text{ }^\circ\text{C}$. For resistance a zero calibration is performed at least every 12 hours within $\pm 1 \text{ }^\circ\text{C}$ of use. Best measurement uncertainty is based upon 1-year specifications and is read as a portion or percent output plus floor specification. The floor specification is expressed as a fixed value or a portion or percent of the range.

⁵ Based on using the HP 3458A at the temperature (t_{cal}) it was calibrated $\pm 5 \text{ }^\circ\text{C}$ and an auto-calibration (ACAL) was performed within the previous 24 hours ($\pm 1 \text{ }^\circ\text{C}$ of ambient temperature). Best measurement uncertainty is based upon 1-year specifications and is read as a portion or percent output plus floor specification. The floor specification is expressed as a fixed value or a portion or percent of the range.

⁶ Best Measurement Uncertainty does not include the mismatch.

⁷ Ranges are based upon the system combination used:

| Instrument/System | Ranges |
|------------------------------------|--|
| HP 8902A | 2.5 MHz to 1.3 GHz Range 1 & 2 – SWR 1.18:1 Range 3 – SWR 1.4:1 |
| HP 8902A w/ HP 11722A | 2.5 MHz to 1.3 GHz Range 1 & 2 – SWR 1.33:1 Range 3 – SWR 1.5:1 |
| HP 8902A w/ HP 11792A or HP 11793A | (50 to 1300) MHz SWR 1.15:1 (1.3 to 18) GHz SWR 1.25:1 (18 to 26.5) GHz SWR 1.4:1 |

⁸ Best Uncertainties are based upon the AM depths. For depths between 0 % and 9.99 %, the digit uncertainty (resolution) is 0.01 %. For depths between 10 % and 99.9 % FS, the digit uncertainty (resolution) is 0.1 %.

⁹ Best Uncertainties are based upon the peak phase deviations. For deviations between 0 and 3.999, the digit uncertainty (resolution) is 1 Hz. For deviations between 0 and 39.99, the digit uncertainty (resolution) is 10 Hz. For deviations between 40 and 400, the digit uncertainty (resolution) is 100 Hz.

¹⁰ Standards Laboratory parameters and uncertainties are not available for calibrations in the field.

¹¹ *AM* is the amplitude modulation; *FM* is the frequency modulation; and *TI* is the time interval.