



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005,
ANSI/NCSL Z540-1-1994 & ANSI/NCSL Z540.3-2006

AGILENT TECHNOLOGIES ROSEVILLE SERVICE CENTER
 10090 Foothills Blvd
 Roseville, CA 95747
 Scott Arrants Phone: 916 788 5540

CALIBRATION

Valid To: February 29, 2012

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	CMC ^{2,3,4} (±)	Comments
DC Voltage – Generate	(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 µV/V + 2.5 µV 4.9 µV/V + 1.9 µV 3.3 µV/V + 4.7 µV 2.4 µV/V + 48 µV 5.4 µV/V + 40 µV 6.9 µV/V + 520 µV	Fluke 5720A/ 5725A
Fixed Values	10 V	3 µV/V	Fluke 732A
DC Voltage – Measure	(0 to 0.1) V (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1000) V	5.6 µV/V + 1.5 µV 5.2 µV/V + 1.2 µV 4.7 µV/V + 2.5 µV 6.6 µV/V + 45 µV 19 µV/V + 160 µV	HP 3458A/100 PLC option 002

Parameter/Equipment	Range	CMC ^{2,3,4} (\pm)	Comments
DC Current – Generate	(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 A/A + 0.009 μ A 33 μ A/A + 0.008 μ A 34 μ A/A + 0.040 μ A 42 μ A/A + 0.68 μ A 51 μ A/A + 0.00 μ A	Fluke 5720A
	220 mA to 1 A (1 to 2.2) A (2.2 to 11) A	76 μ A/A + 12 μ A 0.015 % - 66 μ A 0.030 % + 400 μ A	Fluke 5720A/5725A
DC Current – Measure	(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	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	(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	CMC ^{2,3,4} (\pm)	Comments
AC Current – Generate			
(0 to 220) μ A	(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 μ A 89 μ A/A + 0.062 μ A 60 μ A/A + 0.062 μ A 0.018 % + 0.062 μ A 0.10 % + 0.09 μ A	Fluke 5720A
220 μ A 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 μ A 0.020 % + 0.051 μ A 0.016 % + 0.052 μ A 0.023 % + 0.12 μ A 0.11 % + 0.67 μ A	
(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 μ A 0.021 % + 0.51 μ A 0.016 % + 0.52 μ A 0.023 % + 0.71 μ A 0.11 % + 5.1 μ A	
(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 μ A 0.021 % + 3.0 μ A 0.017 % + 2.2 μ A 0.024 % + 3.1 μ A 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 μ A 0.035 % + 26 μ A 0.044 % + 83 μ A 0.055 % + 72 μ A 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 μ A 0.088 % + 290 μ A 0.31 % + 0.64 mA	
AC Current – Measure			
(0 to 100) μ A	(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	CMC ^{2,3,4} (\pm)	Comments
AC Current – Measure (cont)			
(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			
(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	CMC ^{2,3,4} (\pm)	Comments
AC Voltage – Generate (cont)			
(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			
(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	CMC ^{2,4} (±)	Comments
AC Voltage – Measure (cont)			
(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 μV/V + 4.1 μV 70 μV/V + 2.1 μV 0.014 % + 2.3 μV 0.03 % + 2.6 μV 0.08 % + 2.3 μV 0.3 % + 15 μV 1 % + 28 μV 1.5 % + 20 μV 4 % + 74 μV 4 % + 83 μV 15 % + 110 μV	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 μV/V + 41 μV 70 μV/V + 21 μV 0.014 % + 22 μV 0.03 % + 22 μV 0.08 % + 22 μV 0.3 % + 120 μV 1 % + 300 μV 1.5 % + 210 μV 4 % + 730 μV 4 % + 830 μV 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 μV/V + 420 μV 70 μV/V + 220 μV 0.014 % + 240 μV 0.03 % + 250 μV 0.08 % + 220 μV 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	CMC ^{2,3,11} (±)	Comments
AC Voltage Flatness – Generate			
0.3 mV to 3.5 V	(10 to 30) Hz 30 Hz to 120 kHz	0.27 % 0.14 %	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 % 0.62 % 0.80 % 2.4 %	
(0.3 to 3) mV	120 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.22 % 0.37 % 0.55 % 1.4 %	
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 % 0.21 % 0.38 % 0.86 %	
AC Voltage Flatness – Measure			
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	CMC ^{2,3,4} (±)	Comments
Resistance – Generate			
0.1 Ω (1, 10) Ω 100 Ω (1, 10, 100) kΩ	DC to 1 MHz, direct measurement	1 % of value 0.1 % of value 0.03 % of value 0.03 % of value	16074A DUT box calibration R-L standard, BNC 3 terminal
Shunt 15 A 0.1 Ω, 25 W	Dissipated power: 0.3 Amps to full power	0.014 %	Guildline 9230-15
Shunt 100A 0.01 Ω, 100 W	≤ 25W	0.014 %	Guildline 9230-100
Shunt 300A 0.01 Ω, 90 W	≤ 25W	0.012 %	Guildline 9230-300
Shunt 1000A 0.0001 Ω, 100 W	≤ 25W	0.036 %	Guildline 9230-1000 Option 92310 Forced Air Cooling
Capacitance – Generate			
Direct Measure (1, 10) pF (100, 1000) pF (0.01, 0.1, 1) μF	1 kHz	0.01 % 0.01 % 0.01 %	16380A/16380C standard air capacitor set, BNC 4 terminal pair
Algorithmic Derivation 1 pF	1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	0.05 % 0.06 % 0.10 % 0.2 % 0.3 % 1.0 % 1.5 %	
(10, 100) pF	(1, 2) MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	0.025 % 0.03 % 0.04 % 0.06 % 0.15 % 0.20 %	

Parameter/Range	Frequency	CMC ^{2,3,11} (±)	Comments
Capacitance Generate – (cont)			
Algorithmic Derivation 1000 pF	1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	0.05 % 0.06 % 0.10 % 0.15 % 0.20 % 0.50 % 0.70 %	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 % 0.04 %	
(0.01, 0.1) μF 1 μF	100 kHz	0.05 % 0.1 %	
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 300) Hz (10 to 150) Hz	0.4 % 0.4 % 0.4 % 0.4 % 0.4 %	Fluke 5720A
Voltage Ratio – Generate Decades			
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	CMC ² (±)	Comments
Electrical Calibration of Thermocouple Indicators – 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	CMC ^{2, 10} (±)	Comments
<p>Amplitude Modulation – Measure⁷</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 50 kHz, depth: 5% to 99%</p> <p>rate: 20 Hz to 100 kHz, depth: to 99%</p> <p>rate: 50 Hz to 10 kHz, depth: 5% to 99%</p> <p>+ Down converter 11793A rate: 20 Hz to 10 kHz, depth: to 99%</p>
<p>Frequency Modulation – Measure⁸</p> <p>(0.25 to 10) MHz (0 to <4) kHz_{Peak} FM (≥ 4 to < 40) kHz_{Peak} FM</p> <p>(10 to 1300) MHz (0 to <4) kHz_{Peak} FM (≥ 4 to < 40) kHz_{Peak} FM (≥ 40 to < 400) kHz_{Peak} FM</p> <p>(10 to 1300) MHz (0 to <4) kHz_{Peak} FM (≥ 4 to < 40) kHz_{Peak} FM (≥ 40 to < 400) kHz_{Peak} FM</p>	<p>0.024FM + 2.6 Hz_{Peak} 0.024FM + 10 Hz_{Peak}</p> <p>0.012FM + 2.6 Hz_{Peak} 0.012FM + 12 Hz_{Peak} 0.012FM + 0.11 kHz_{Peak}</p> <p>0.059• FM + 2.8 Hz_{Peak} 0.059• FM + 13 Hz_{Peak} 0.059• FM + 0.12 kHz_{Peak}</p>	<p>HP 8902 measuring receiver:</p> <p>rate: 20 Hz to 10 kHz, ≤40 kHz</p> <p>rate: 50 Hz to 100 kHz, ≤400 kHz</p> <p>rate: 20 Hz to 200 kHz, ≤400 kHz</p>

Parameter/Equipment/Range	CMC ^{2, 10} (±)	Comments
<p>Frequency Modulation – Measure (cont)⁸</p> <p>10 MHz to 26.5 GHz (10 to 1300) MHz (0 to <4) kHz_{Peak} FM (≥ 4 to < 40) kHz_{Peak} FM (≥ 40 to < 400) kHz_{Peak} FM</p> <p>(>1.3 to 6.2) GHz (0 to <4) kHz_{Peak} FM (≥ 4 to < 40) kHz_{Peak} FM (≥ 40 to < 400) kHz_{Peak} FM</p> <p>(>6.2 to 12.4) GHz (0 to <4) kHz_{Peak} FM (≥ 4 to < 40) kHz_{Peak} FM (≥ 40 to < 400) kHz_{Peak} FM</p> <p>(>12.4 to 18.6) GHz (0 to <4) kHz_{Peak} FM (≥ 4 to < 40) kHz_{Peak} FM (≥ 40 to < 400) kHz_{Peak} FM</p> <p>(>18.6 to 26.5) GHz (0 to <4) kHz_{Peak} FM (≥ 4 to < 40) kHz_{Peak} FM (≥ 40 to < 400) kHz_{Peak} FM</p> <p>10 MHz to 26.5 GHz (10 to 1300) MHz (0 to <4) kHz_{Peak} FM (≥ 4 to < 40) kHz_{Peak} FM (≥ 40 to < 400) kHz_{Peak} FM</p> <p>(>1.3 to 6.2) GHz (0 to <4) kHz_{Peak} FM (≥ 4 to < 40) kHz_{Peak} FM (≥ 40 to < 400) kHz_{Peak} FM</p> <p>(>6.2 to 12.4) GHz (0 to <4) kHz_{Peak} FM (≥ 4 to < 40) kHz_{Peak} FM (≥ 40 to < 400) kHz_{Peak} FM</p> <p>(>12.4 to 18.6) GHz (0 to <4) kHz_{Peak} FM (≥ 4 to < 40) kHz_{Peak} FM (≥ 40 to < 400) kHz_{Peak} FM</p>	<p>0.012FM + 2.4 Hz_{Peak} 0.012FM + 12 Hz_{Peak} 0.012FM + 0.10 kHz_{Peak}</p> <p>0.0099FM + 10 Hz_{Peak} 0.012FM + 12 Hz_{Peak} 0.012FM + 0.10 kHz_{Peak}</p> <p>0.0075FM + 24 Hz_{Peak} 0.012FM + 12 Hz_{Peak} 0.012FM + 85 Hz_{Peak}</p> <p>0.0049FM + 52 Hz_{Peak} 0.011FM + 36 Hz_{Peak} 0.012FM + 0.11 kHz_{Peak}</p> <p>0.0035FM + 80 Hz_{Peak} 0.011FM + 46 Hz_{Peak} 0.012FM + 0.10 kHz_{Peak}</p> <p>0.059FM + 2.8 Hz_{Peak} 0.059FM + 14 Hz_{Peak} 0.059FM + 0.12 kHz_{Peak}</p> <p>0.058FM + 5.2 Hz_{Peak} 0.059FM + 14 Hz_{Peak} 0.059FM + 0.12 kHz_{Peak}</p> <p>0.055FM + 15 Hz_{Peak} 0.059FM + 14 Hz_{Peak} 0.059FM + 0.12 kHz_{Peak}</p> <p>0.050FM + 37 Hz_{Peak} 0.059FM + 15 Hz_{Peak} 0.059FM + 0.12 kHz_{Peak}</p>	<p>HP 8902 measuring receiver: 11793A Down Converter</p> <p>rate: 50 Hz to 100 kHz, ≤400 kHz</p> <p>rate: 20 Hz to 200 kHz, ≤400 kHz</p>

Parameter/Equipment/Range	CMC ^{2, 10} (±)	Comments
Frequency Modulation – Measure (cont) (>18.6 to 26.5) GHz (0 to <4) kHz _{Peak} FM (≥ 4 to < 40) kHz _{Peak} FM (≥ 40 to < 400) kHz _{Peak} FM	 $0.045FM + 60 \text{ Hz}_{\text{Peak}}$ $0.059FM + 16 \text{ Hz}_{\text{Peak}}$ $0.059FM + 0.12 \text{ kHz}_{\text{Peak}}$	HP 8902 measuring receiver: 11793A down converter rate: 20 Hz to 200 kHz, ≤400 kHz

Parameter/Range	Frequency	CMC ² (±)	Comments
Digital Modulation – Measure Carrier: 2 MHz to 2.65 GHz Error Vector Magnitude for Modulation Types: MSK, GMSK, BPSK, DQPSK, π/4DQPSK, 8PSK, 16QAM and 32QAM, QPSK Phase Error for Modulation Types: MSK, GMSK, BPSK, DQPSK, n/4DQPSK, 8PSK, 16QAM and 32QAM, QPSK Error Vector Magnitude for FSK Modulation	Mod Frequency Span: (1 to 100) kHz (0.1 to 1) MHz 1 MHz to 2.65 GHz (1 to 100) kHz (0.1 to 1) MHz 1 MHz to 2.65 GHz Mod Frequency: 3.2 kHz 1.152 kHz	 $0.33 \% \text{ rms}$ $0.51 \% \text{ rms}$ $1.0 \% \text{ rms}$ 0.18° rms 0.34° rms 0.57° rms $0.54 \% \text{ rms}$ $1.5 \% \text{ rms}$	 HP 89441A vector signal analyzer

Parameter/Range	Frequency	CMC ² (±)	Comments
RF Absolute Power – Measure ^{3,6}			
(-30 to 10) dBm (10 to 20) dBm	100 kHz to 2 GHz	0.13 dB 0.21 dB	8483A
(10 to 25) dBm (25 to 35) dBm	100 kHz to 4.2 GHz	0.10 dB 0.22 dB	8482H
(-30 to 10) dBm (10 to 20) dBm		0.11 dB 0.15 dB	8482A
(-10 to 25) dBm (25 to 35) dBm	10 MHz to 18 GHz	0.28 dB 0.31 dB	8481H
(-30 to 10) dBm (10 to 20) dBm		0.28 dB 0.30 dB	8481A
(-70 to -30) dBm (-30 to -20) dBm		0.35 dB 0.35 dB	8481D
(-70 to -30) dBm (-30 to -20) dBm	50 MHz to 18 GHz	0.33 dB 0.32 dB	8484A
(-30 to 10) dBm (10 to 20) dBm	50 MHz to 26.5 GHz	0.19 dB 0.21 dB	8485A
(-70 to -30) dBm (-30 to -20) dBm		0.21 dB 0.23 dB	8485D
(-30 to 10) dBm (10 to 20) dBm	50 MHz to 50 GHz	0.53 dB 0.72 dB	8487A

Parameter/Range	Frequency	CMC ² (±)	Comments
Tuned RF Power –			
Absolute – Measure ⁶			
(≤ +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	
(< -120 to ≥ -127) dBm		0.34 dB	
Relative – Measure			
(≤ +10 to ≥ +2) dB	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) dB		0.071 dB	
(< -12 to ≥ -22) dB		0.081 dB	
(< -22 to ≥ -31) dB		0.088 dB	
(< -31 to ≥ -40) dB		0.095 dB	
(< -40 to ≥ -50) dB		0.12 dB	
(< -50 to ≥ -61) dB		0.15 dB	
(< -61 to ≥ -71) dB		0.16 dB	
(< -71 to ≥ -80) dB		0.17 dB	
(< -80 to ≥ -90) dB		0.19 dB	
(< -90 to ≥ -100) dB		0.22 dB	
(< -100 to ≥ -110) dB		0.23 dB	
(< -110 to ≥ -120) dB	0.27 dB		
(< -120 to ≥ -127) dB	0.30 dB		

Parameter/Range	Frequency	CMC ² (±)	Comments
RF Absolute Power – Generate ⁵			
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 3335A 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 3335A 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 (-60 to -98) dBm	200 Hz to 25 MHz (25 to 80) MHz 200 Hz to 25 MHz (25 to 80) MHz	0.34 dB 0.52 dB 0.47 dB 0.81 dB	
In 0.01 dB steps (0 to -1.99) dBm	200 kHz to 80 MHz SWR ≤ 1.5:1	0.036 dB	HP 3335A with BNC(f)

Parameter/Range	Frequency	CMC ² (±)	Comments
RF Absolute Power – Generate ⁵ – (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 (≥ 2 to ≤ 20) GHz SWR ≤ 1.6:1	1.4 dB 1.5 dB	HP 83650B, 2.4 mm(m)
> -10 dBm	10 MHz to 2 GHz SWR ≤ 1.6:1 (≥ 2 to ≤ 20) GHz SWR ≤ 1.6:1 (> 20 to ≤ 40) GHz SWR ≤ 1.8:1 (> 40 to ≤ 50) GHz SWR ≤ 2.0:1	0.72 dB 0.84 dB 1.1 dB 1.0 dB	HP 83650B, 2.4 mm(m)
> -60 dBm	10 MHz to 2 GHz SWR ≤ 1.6:1 (≥ 2 to ≤ 20) GHz SWR ≤ 1.6:1 (> 20 to ≤ 40) GHz SWR ≤ 1.8:1 (> 40 to ≤ 50) GHz SWR ≤ 2.0:1	1.1 dB 1.2 dB 1.4 dB 2.4 dB	HP 83650B, 2.4 mm(m)
≤ -60 dBm	10 MHz to 2 GHz SWR ≤ 1.6:1 (≥ 2 to ≤ 20) GHz SWR ≤ 1.6:1 (> 20 to ≤ 40) GHz SWR ≤ 1.8:1 (> 40 to ≤ 50) GHz SWR ≤ 2.0:1	1.7 dB 1.8 dB 2.0 dB 3.0 dB	HP 83650B, 2.4 mm(m)

Parameter/Range	Frequency	CMC ² (±)	Comments
Power Sensor Calibration Factor	100 kHz to 5 MHz 5 MHz to 17 GHz (17 to 26.5) GHz (26.5 to 50) GHz	1.0 % 1.1 % 2.5 % 4.4 %	Orion Test System
Thermal Noise Figure System – Measure (0 to 30) dB	10 MHz to 1.6 GHz SWR 1.7:1 ENR (14 to 16) dB	0.21 dB	HP 8970A w/ HP 346B and APC-3.5 + Down Converter 8970B
Thermal Noise Generate – ENR (14 to 16) dB	10 MHz to 18 GHz SWR 1.25:1 (18 to 26.5) GHz SWR 1.35:1	0.21 dB 0.22 dB	HP 346B w/ APC-3.5 HP 346C w/ APC-3.5
Pulse – Generate Transition Time Width RMS Jitter – Period, Delay and Width	10 % to 90 % 150 ps to 10 ns (10 to < 100) ns $\geq 100 \mu\text{s}$ to < 10 ms (≥ 10 to < 100) ms (≥ 100 to < 0.99) ms 33 MHz to 3.0 GHz	0.13 ns 0.13 ns (0.013 * Width) + 1.2 ns (0.013 * Width) + 0.14 μs (0.012 * Width) + 2.0 ns (0.012 * Width) + 0.19 μs 10 ps	HP 8133A HP 8133A HP 8161A HP 8161A HP 8161A HP 8161A HP 8133A
Pulse – Measure RMS Jitter – Period, Delay and Width	33 MHz to 3.0 GHz	6.6 ps	HP 54124T or HP 86100

Parameter/Equipment	Range	CMC (\pm)	Comments
CISPR 16 Pulse Response			
Quasi-Peak detector response			IGUU 2916
Band A	(1 to 100) Hz	0.10 dB	
Band B	(1 to 20) Hz	0.11 dB	
Band C	(1 to 20) Hz	0.26 dB	
Band D	(1 to 20 Hz)	0.26 dB	
Quasi-Peak to Peak detector relative response ratio			
Band A	25 Hz	0.10 dB	
Band B, C, D	100 Hz		
Quasi-Peak to Average detector relative response ratio			
Band A	25 Hz	0.10 dB	
Band B	500 Hz		
Band C, D	5 kHz		
Quasi-Peak absolute amplitude			E4419B and E9304A
Band A	25 Hz	0.40 dB	
Band B	100 Hz	0.40 dB	
Band C	100 Hz	0.60 dB	

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

Parameter/Range	Frequency	CMC ² (±)	Comments
Attenuation – Generate (cont.)			
Coaxial, 10 dB Step			
0 dB	50 MHz to 2 GHz (2 to 4) GHz	±0.027 dB ±0.029 dB	HP 8496G w/ Type- N(f)
10 dB	50 MHz to 2 GHz (2 to 4) GHz	±0.031 dB ±0.030 dB	
20 dB	50 MHz to 2 GHz (2 to 4) GHz	±0.033 dB ±0.032 dB	
30 dB	50 MHz to 2 GHz (2 to 4) GHz	±0.036 dB ±0.035 dB	
40 dB	50 MHz to 2 GHz (2 to 4) GHz	±0.054 dB ±0.048 dB	
50 dB	50 MHz to 2 GHz (2 to 4) GHz	±0.062 dB ±0.057 dB	
60 dB	50 MHz to 2 GHz (2 to 4) GHz	±0.064 dB ±0.058 dB	
70 dB	50 MHz to 2 GHz (2 to 4) GHz	±0.070 dB ±0.060 dB	
80 dB	50 MHz to 2 GHz (2 to 4) GHz	±0.084 dB ±0.068 dB	
90 dB	50 MHz to 2 GHz (2 to 4) GHz	±0.091 dB ±0.074 dB	
100 dB	50 MHz to 2 GHz (2 to 4) GHz	±0.093 dB ±0.076 dB	
110 dB	50 MHz to 2 GHz (2 to 4) GHz	±0.11 dB ±0.077 dB	

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

Parameter/Range	CMC ² (±)	Comments
Reflection S ₁₁ / S ₂₂ – Measure		
5 Hz to 200 MHz (0 to 1.0) lin	(± 0.004 to ± 0.020) lin (± 180 to ± 2.4) deg	50 Ohm network analyzer HP3577A S parameter 35677A/87512A-S-11 Type-N precision cal kit HP85032B, ver kit 85055A
100 kHz to 200 MHz (0 to 1.0) lin	(± 0.0059 to ± 0.021) lin (± 180 to ± 2.5) 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 8753ES S parameter 85047A
300 kHz to 1.3 GHz (0 to 1.0) lin	(± 0.0071 to ± 0.034) lin (± 180 to ± 2.0) deg	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 to 3) GHz (0 to 1.0) lin	(± 0.0051 to ± 0.026) lin (± 180 to ± 1.5) deg	
(3 to 6) GHz (0 to 1.0) lin	(± 0.011 to ± 0.050) lin (± 180 to ± 2.9) deg	
300 kHz to 1.3 GHz (0 to 1.0) lin	(± 0.0019 to ± 0.0072) lin (± 180 to ± 0.41) deg	Network analyzer HP8753ES APC 7mm precision cal kit ET33717, ver kit 85051A
(1.3 to 3) GHz (0 to 1.0) lin	(± 0.0036 to ± 0.010) lin (± 180 to ± 0.59) deg	
(3 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
(0 to 0.01) lin	(± 180 to ± 6.0) deg	source: HP83631A/B
(0.01 to 0.1) lin	(± 6.0 to ± 0.70) deg	cable: HP85132C
(0.1 to 0.5) lin	(± 0.70 to ± 0.26) deg	7 mm precision cal kit ET33733,
(0.5 to 1.0) lin	(± 0.26 to ± 0.20) deg	ver kit 85051A

Parameter/Range	CMC ² (\pm)	Comments	
Reflection S ₁₁ / S ₂₂ – Measure			
(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 ± 6.6) deg		
(0.01 to 0.1) lin	(± 6.6 to ± 0.83) deg		
(0.1 to 0.5) lin	(± 0.83 to ± 0.34) deg		
(0.5 to 1.0) lin	(± 0.34 to ± 0.29) deg		
(8 to 18) GHz (0 to 1) lin	(± 0.0016 to ± 0.0034) lin		
(0 to 0.01) lin	(± 180 to ± 9.5) deg		
(0.01 to 0.1) lin	(± 9.5 to ± 1.2) deg		
(0.1 to 0.5) lin	(± 1.2 to ± 0.51) deg		
(0.5 to 1.0) lin	(± 0.51 to ± 0.46) 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, Ver kit 85055A
(0 to 0.01) lin	(± 180 to ± 8.3) deg		
(0.01 to 0.1) lin	(± 8.3 to ± 0.93) deg		
(0.1 to 0.5) lin	(± 0.93 to ± 0.30) deg		
(0.5 to 1.0) lin	(± 0.30 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 ± 0.40) 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 ± 0.78) 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, ver kit 85053A	
(0 to 0.01) lin	(± 180 to ± 13) deg		
(0.01 to 0.1) lin	(± 13 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	CMC ² (±)	Comments
Reflection S ₁₁ / S ₂₂ – Measure (cont)		
(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 ± 1.8) deg	
(0.1 to 0.5) lin	(± 1.8 to ± 0.53) deg	
(0.5 to 1.0) lin	(± 0.53 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 ± 19) deg	
(0.01 to 0.1) lin	(± 19 to ± 2.2) deg	
(0.1 to 0.5) lin	(± 2.2 to ± 0.71) deg	
(0.5 to 1.0) lin	(± 0.71 to ± 0.60) 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 ± 2.5) deg	
(0.1 to 0.5) lin	(± 2.5 to ± 0.87) deg	
(0.5 to 1.0) lin	(± 0.87 to ± 0.75) deg	
45 MHz to 2 GHz (0 to 1) lin	(± 0.0080 to ± 0.012) lin	Network analyzer: HP8510B/C S parameter: HP8517A source: HP83651A/B cable: HP85133E 2.4mm precision cal kit HP85056A, ver kit 85057B
(0 to 0.01) lin	(± 180 to ± 54) deg	
(0.01 to 0.1) lin	(± 54 to ± 4.7) deg	
(0.1 to 0.5) lin	(± 4.7 to ± 1.1) deg	
(0.5 to 1.0) lin	(± 1.1 to ± 0.80) deg	
(2 to 20) GHz (0 to 1) lin	(± 0.0080 to ± 0.015) lin	
(0 to 0.01) lin	(± 180 to ± 54) deg	
(0.01 to 0.1) lin	(± 54 to ± 5.0) deg	
(0.1 to 0.5) lin	(± 5.0 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 ± 0.021) 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	CMC ² (±)	Comments
Reflection S ₁₁ / S ₂₂ – Measure (cont) (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	(± 0.016 to ± 0.033) lin (± 180 to ± 180) deg (± 180 to ± 10) deg (± 10 to ± 2.8) deg (± 2.8 to ± 2.6) 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 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 ± 1.1) deg (± 0.056 to ± 0.19) dB (± 1.1 to ± 3.0) deg (± 0.041 to ± 0.063) dB (± 0.41 to ± 0.46) deg (± 0.063 to ± 0.088) dB (± 0.46 to ± 0.62) deg (± 0.088 to ± 0.28) dB (± 0.62 to ± 1.9) deg (± 0.056 to ± 0.076) dB (± 0.87 to ± 1.3) deg (± 0.076 to ± 0.10) dB (± 1.3 to ± 1.4) deg (± 0.10 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, ver kit 85055A 50 Ohm Network analyzer 8753ES Type-N precision cal kit 85032B

Parameter/Range	CMC ² (±)	Comments
Transmission S ₁₂ / S ₂₁ – Measure (cont)		
5 Hz to 200 MHz (0 to 20) dB	(± 0.094 to ± 0.13) dB (± 1.2 to ± 1.5) deg	50 Ohm Network analyzer 8753ES Type-N precision cal kit 85032B
(20 to 40) dB	(± 0.13 to ± 0.16) dB (± 1.5 to ± 1.6) deg	
(40 to 60) dB	(± 0.16 to ± 0.50) dB (± 1.6 to ± 3.5) deg	
100 kHz to 200 MHz (0 to 20) dB	(± 0.056 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 ± 1.2) deg	
(40 to 60) dB	(± 0.061 to ± 0.28) dB (± 1.2 to ± 4.4) 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 ± 0.19) dB (± 0.85 to ± 1.4) deg	
300 kHz to 1.3 GHz (0 to 20) dB	(± 0.091 to ± 0.11) dB (± 0.62 to ± 0.95) deg	
(20 to 40) dB	(± 0.11 to ± 0.11) dB (± 0.95 to ± 1.5) deg	
(40 to 60) dB	(± 0.11 to ± 0.22) dB (± 1.6 to ± 1.7) deg	
300 kHz to 1.3 GHz (0 to 20) dB	(± 0.028 to ± 0.048) dB (± 0.29 to ± 0.40) deg	Network analyzer HP8753ES APC 7mm precision cal kit HP85031B, ver kit 85051A
(20 to 40) dB	(± 0.048 to ± 0.075) dB (± 0.40 to ± 0.56) deg	
(40 to 60) dB	(± 0.075 to ± 0.28) dB (± 0.56 to ± 1.9) deg	

Parameter/Range	CMC ² (±)	Comments
Transmission S ₁₂ / S ₂₁ – Measure (cont.)		
(1.3 to 3) GHz (0 to 20) dB	(± 0.033 to ± 0.055) dB (± 0.38 to ± 0.46) deg	Network analyzer HP8753ES APC 7mm precision cal kit HP85031B
(20 to 40) dB	(± 0.055 to ± 0.081) dB (± 0.46 to ± 0.60) deg	
(40 to 60) dB	(± 0.081 to ± 0.31) dB (± 0.60 to ± 2.1) deg	
(3 to 6) GHz (0 to 20) dB	(± 0.047 to ± 0.069) dB (± 1.4 to ± 1.1) deg	
(20 to 40) dB	(± 0.069 to ± 0.10) dB (± 1.1 to ± 1.2) deg	
(40 to 60) dB	(± 0.10 to ± 0.48) dB (± 1.2 to ± 3.3) deg	
45 MHz to 2 GHz (0 to 20) dB	(± 0.012 to ± 0.022) 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	(± 0.022 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	(± 0.012 to ± 0.018) dB (± 1.0 to ± 1.1) deg	
(20 to 40) dB	(± 0.018 to ± 0.035) dB (± 1.1 to ± 1.2) deg	
(40 to 60) dB	(± 0.035 to ± 0.29) dB (± 1.2 to ± 2.9) deg	

Parameter/Range	CMC ² (±)	Comments
Transmission S ₁₂ / S ₂₁ – Measure (cont)		
(8 to 18) GHz (0 to 20) dB	(± 0.014 to ± 0.018) dB (± 2.1 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 ± 4.7) 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, ver kit 85055A
(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 ± 0.018) dB (± 1.1 to ± 1.1) deg	
(20 to 40) dB	(± 0.018 to ± 0.035) dB (± 1.1 to ± 1.2) deg	
(40 to 60) dB	(± 0.035 to ± 0.29) dB (± 1.2 to ± 2.9) deg	
(8 to 18) GHz (0 to 20) dB	(± 0.020 to ± 0.023) dB (± 2.2 to ± 2.2) deg	
(20 to 40) dB	(± 0.023 to ± 0.052) dB (± 2.2 to ± 2.4) deg	
(40 to 60) dB	(± 0.052 to ± 0.41) dB (± 2.4 to ± 4.7) deg	

Parameter/Equipment/Range	CMC ² (±)	Comments
Transmission S ₁₂ / S ₂₁ – Measure (cont)		
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 85131A/C 3.5mm precision cal kit ET33700, ver kit 85053A
(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 ± 0.018) dB (± 1.0 to ± 1.1) deg	
(20 to 40) dB	(± 0.018 to ± 0.035) dB (± 1.1 to ± 1.2) deg	
(40 to 60) dB	(± 0.035 to ± 0.28) dB (± 1.2 to ± 2.8) deg	
(8 to 20) GHz (0 to 20) dB	(± 0.016 to ± 0.019) dB (± 2.4 to ± 2.4) deg	
(20 to 40) dB	(± 0.019 to ± 0.052) dB (± 2.4 to ± 2.6) deg	
(40 to 60) dB	(± 0.052 to ± 0.43) dB (± 2.6 to ± 5.1) deg	
(20 to 26.5) GHz (0 to 20) dB	(± 0.020 to ± 0.028) dB (± 3.1 to ± 3.2) deg	
(20 to 40) dB	(± 0.028 to ± 0.16) dB (± 3.2 to ± 4.0) deg	
(40 to 60) dB	(± 0.16 to ± 1.7) dB (± 4.0 to ± 13) deg	

Parameter/Range	CMC ² (±)	Comments
Transmission S ₁₂ / S ₂₁ – Measure (cont)		
45 MHz to 2 GHz (0 to 20) dB	(± 0.024 to ± 0.028) 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, ver kit 85057B
(20 to 40) dB	(± 0.027 to ± 0.12) dB (± 0.28 to ± 0.92) deg	
(40 to 60) dB	(± 0.12 to ± 1.2) dB (± 0.92 to ± 7.8) deg	
(2 to 20) GHz (0 to 20) dB	(± 0.049 to ± 0.050) dB (± 2.3 to ± 2.3) deg	
(20 to 40) dB	(± 0.050 to ± 0.056) dB (± 2.3 to ± 2.3) deg	
(40 to 60) dB	(± 0.056 to ± 0.25) dB (± 2.3 to ± 3.6) deg	
(20 to 40) GHz (0 to 20) dB	(± 0.11 to ± 0.12) dB (± 4.6 to ± 4.6) deg	
(20 to 40) dB	(± 0.12 to ± 0.22) dB (± 4.6 to ± 5.3) deg	
(40 to 60) dB	(± 0.22 to ± 2.1) dB (± 5.3 to ± 16) deg	
(40 to 50) GHz (0 to 20) dB	(± 0.14 to ± 0.16) dB (± 5.7 to ± 5.8) deg	
(20 to 40) dB	(± 0.16 to ± 0.79) dB (± 5.8 to ± 9.8) deg	
(40 to 60) dB	(± 0.79 to ± 17) dB (± 9.8 to ± 63) deg	

III. Optical Quantities

Parameter/Equipment	Range	CMC ² (±)	Comments
Laser Optical Power – Measure	(80 to 1000) μW	12 μW	UDT Instruments S370/247
Laser Wavelength – Measure	633 nm	5.1 x 10 ⁻⁶ nm	HP 5517B/5508A
Fiber Optics Power – Measure			
850 nm	(-60 to 0) dBm	0.079 dB	81520A
1310 nm	(-60 to -50) dBm	0.056 dB	81624B
1550 nm	(-50 to 10) dBm	0.053 dB	
Fiber Optics Power – Generate			
(600 to 1020) nm	(-60 to 10) dBm (10 to 27) dBm	0.11 dB 0.12 dB	81250B
(970 to 1630) nm	(-60 to 10) dBm (10 to 33) dBm	0.083 dB 0.085 dB	81624B
Fiber Optics Wavelength – Measure	850 nm 1310 nm 1530 nm 1550 nm	3.2 pm 0.37 pm 0.37 pm 0.37 pm	86120B
Fiber Optics Wavelength – Generate	(700 to 1270) nm (1270 to 1650) nm	3.5 x 10 ⁻³ nm 2.0 x 10 ⁻⁴ nm	81520A 81624B

IV. Mechanical

Parameter/Equipment	Range	CMC ² (±)	Comments
Pressure – Measure ³	(20 to 31) in of HGA	0.01 in of HGA	DH Instruments RPM 1

V. Thermodynamics

Parameter/Equipment	Range	CMC ² (±)	Comments
Temperature – Measure	-1 °C to 41 °C	0.01 °C	Hart Scientific 1529 Hart Scientific 5610

VI. Time and Frequency

Parameter/Equipment	Range	CMC ^{2, 10} (±)	Comments
Time Interval – Measure	60 ps to 1 μs 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 μs 10 ns to 10s	12 ps 13 ps $1.4 \times 10^{-3} TI + 13 \text{ ps}$ $1.1 \times 10^{-3} TI + 17 \text{ ps}$ $9.5 \times 10^{-4} TI + 26 \text{ ps}$ $8.0 \times 10^{-4} TI + 56 \text{ ps}$ $7.6 \times 10^{-4} TI + 110 \text{ ps}$ $7.2 \times 10^{-4} TI + 210 \text{ ps}$ $6.8 \times 10^{-4} TI + 540 \text{ ps}$ $7.0 \times 10^{-4} TI + 1000 \text{ ps}$ $5.4 \times 10^{-4} TI + 2.3 \text{ ns}$ 2.9 ns	HP 54124T, includes transition time; Δt is the time interval in seconds. HP 5334B/HP 5071A cesium beam standard
Frequency – Generate	5 MHz, 10 MHz	10 pHz/Hz	HP 5071A cesium beam frequency standard, 2-½ day average, GPS disciplined, Datum 8040
Frequency – Measure	1 Hz to 40 GHz	50 pHz/Hz	HP 53132A HP 5352B

Standards Laboratory

VII. Electrical – RF/Microwave ⁹

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

Parameter/Equipment	Range/Frequency	CMC 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	0.15 dB	WR-90
		(12.4 to 18) GHz	0.14 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		0.015 dB		

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

VIII. Mechanical

Parameter/Equipment	Range	CMC 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.

² Calibration and Measurement Capability (CMC) 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 or nearly ideal measuring equipment. Calibration and Measurement Capabilities represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of $k = 2$. The actual measurement uncertainty of a specific calibration performed by the laboratory may be greater than the CMC due to the behavior of the customer's device and to influences from the circumstances of the specific calibration.

³ Based on using the standard at the temperature the Fluke 5720A/5725A was calibrated ($\pm 5\text{ }^{\circ}\text{C}$) 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. CMC 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.

⁴ Based on using the HP 3458A at the temperature (tcal) 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). CMC 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 Calibration Measurement Capability does not include the mismatch.

⁶ 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

⁷ Calibration Measurement Capabilities 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 %.

⁸ Calibration Measurement Capabilities 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.

⁹ Standards Laboratory parameters and uncertainties are not available for calibrations in the field.

¹⁰ *AM* is the amplitude modulation Depth; *FM* is the frequency modulation Deviation; and *TI* is the time interval.

¹¹ All readings stated in percent mean percent of reading



World Class Accreditation

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AGILENT TECHNOLOGIES ROSEVILLE SERVICE CENTER

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 the requirements of ANSI/NCSL Z540.3-2006 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 8 January 2009).



Presented this 5th day of May 2010.

A handwritten signature in black ink, appearing to read "Peter Abney", written over a horizontal line.

President & CEO
For the Accreditation Council
Certificate Number 1920.01
Valid to February 29, 2012
Revised August 3, 2010

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