

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

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CALIBRATION

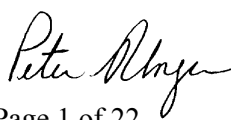
Valid To: November 30, 2011

Certificate Number: 2863.01

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

I. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2, 4, 5} (±)	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	4.0 $\mu\text{V}/\text{V}$ + 2.6 μV 7.2 $\mu\text{V}/\text{V}$ + 1.7 μV 6.7 $\mu\text{V}/\text{V}$ + 4.6 μV 6.0 $\mu\text{V}/\text{V}$ + 37 μV 8.5 $\mu\text{V}/\text{V}$ + 53 μV 9.4 $\mu\text{V}/\text{V}$ + 570 μV	Fluke 5700A/ 5725A
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 $\mu\text{V}/\text{V}$ + 1.5 μV 5.2 $\mu\text{V}/\text{V}$ + 1.2 μV 4.7 $\mu\text{V}/\text{V}$ + 2.5 μV 6.6 $\mu\text{V}/\text{V}$ + 45 μV 19 $\mu\text{V}/\text{V}$ + 160 μV	HP 3458A/100 PLC option 002
DC Current – Generate	(0 to 220) μA 220 μA to 2.2 mA (2.2 to 22) mA (22 to 100) mA (100 to 220) mA 220 mA to 1 A (1 to 2.2) A (2.2 to 11) A	46 $\mu\text{V}/\text{V}$ + 0.010 μV 50 $\mu\text{V}/\text{V}$ + 0.009 μV 51 $\mu\text{V}/\text{V}$ + 0.083 μV 59 $\mu\text{V}/\text{V}$ + 0.84 μV 74 $\mu\text{V}/\text{V}$ - 0.73 μV 80 $\mu\text{V}/\text{V}$ + 25 μV 0.015 % - 46 μV 0.03 % + 400 μV	Fluke 5700A



Parameter/Equipment	Range	CMC ^{2, 4, 5} (\pm)	Comments
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 0.37 m Ω 2.6 m Ω 3.0 m Ω 4.1 m Ω 13 m Ω 36 m Ω 130 m Ω 0.25 Ω 1.4 Ω 2.7 Ω 20 Ω 42 Ω 400 Ω 1.5 k Ω 13 k Ω	Fluke 5700A
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
AC Current – Generate (10 to 220) μ A 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 (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.054 % + 0.064 μ A 0.025 % + 0.064 μ A 80 μ A/A + 0.064 μ A 0.059 % + 0.42 μ A 0.14 % + 0.10 μ A 0.068 % + 0.051 μ A 0.037 % + 0.047 μ A 0.017 % + 0.052 μ A 0.06 % + 0.42 μ A 0.15 % + 0.84 μ A	Fluke 5700A

Parameter/Range	Frequency	CMC ^{2,4,5} (±)	Comments
AC Current – Generate			
(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	0.068 % + 0.51 µA 0.037 % + 0.47 µA 0.017 % + 0.51 µA 0.06 % + 4.2 µA 0.015 % + 8.5 µA	Fluke 5700A
(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	0.068 % + 4.2 µA 0.037 % + 3.2 µA 0.02 % + 3.0 µA 0.06 % + 42. µA 1.5 mA/A + 0.08 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	0.064 % + 35 µA 0.067 % + 30 µA 0.072 % + 87 µA 0.08 % + 76 µA 8.4 mA/A + 0.076 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 % + 300 µA 3.1 mA/A + 0.63 mA	
AC Current – Measure			
(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	
(1 to 10) mA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz	0.4 % + 3.1 µA 0.15 % + 2.1 µA 0.06 % + 2.1 µA	
(10 to 100) mA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz	0.4 % + 31 µA 0.15 % + 21 µA 0.06 % + 21 µA	
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 µA 0.16 % + 220 µA 0.08 % + 220 µA 0.1 % + 220 µA	

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Parameter/Range	Frequency	CMC ^{2,4,5} (±)	Comments
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	0.052 % + 4.5 μV 0.025 % + 4.7 μV 0.017 % + 4.6 μV 0.042 % + 4.7 μV 0.082 % + 6.9 μV 0.11 % + 13 μV 0.18 % + 27 μV 0.41 % + 35 μV	Fluke 5700A
(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	0.055 % + 4.5 μV 0.025 % + 4.7 μV 0.017 % + 4.6 μV 0.042 % + 4.7 μV 0.082 % + 6.9 μV 0.11 % + 13 μV 0.18 % + 27 μV 0.41 % + 35 μV	
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	0.051 % + 14 μV 0.021 % + 8.5 μV 99 μV/V + 9.3 μV 0.03 % + 10 μV 0.076 % + 26 μV 0.093 % + 26 μV 0.16 % + 39 μV 0.3 % + 88 μV	
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	0.051 % + 83 μV 0.016 % + 24 μV 88 μV/V + 4.4 μV 0.013 % + 14 μV 0.025 % + 66 μV 0.041 % + 130 μV 0.1 % + 350 μV 0.2 % + 850 μV	
(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	0.051 % + 830 μV 0.01 % + 170 μV 87 μV/V + 51 μV 0.013 % + 160 μV 0.024 % + 330 μV 0.05 % + 1.5 mV 1.2 mV/V + 4.2 mV 2.5 mV/V + 7.6 mV	

Parameter/Range	Frequency	CMC ^{2,4,5} (±)	Comments
AC Voltage – Generate (cont)			
(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	0.51 mV/V + 8.4 mV 0.16 mV/V + 2.4 mV 91 μV/V + 740 μV 0.02 % + 3 mV 0.025 % + 3.5 mV 0.51 mV/V + 8.4 mV 0.52 mV/V + 8.7 mV 13 mV/V + 95 mV 4.5 mV/V + 93 mV 11 mV/V + 180 mV	Fluke 5700A
(0 to 250) V max output, 1100 V range	(15 to 50) Hz 50 Hz to 1 kHz 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	0.39 mV/V + 17 mV 0.092 mV/V + 3.0 mV 0.092 mV/V + 2.9 mV 0.092 mV/V + 2.9 mV 0.51 mV/V + 8.9 mV	
(0 to 750) V	(30 to 50) kHz (50 to 100) kHz	0.35 mV/V + 8.9 mV 2.0 mV/V + 30 mV	Fluke 5700A/ 5725A
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	0.03 % + 3.1 μV 0.02 % + 1.2 μV 0.03 % + 1.7 μV 0.1 % + 1.6 μV 0.5 % + 1.3 μV	HP 3458A
(0 to 10) mV	(100 to 300) kHz 300 kHz to 1 MHz (1 to 4) MHz (4 to 8) MHz	7 % + 7.5 μV 20 % + 8.2 μV 4 % + 2.1 μV 1.2 % + 6.6 μV	

Parameter/Range	Frequency	CMC ^{2,5} (±)	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	

Parameter/Range	Frequency	CMC ^{2, 4, 5} (±)	Comments
AC Voltage – Measure (cont) (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	HP 3458A
AC Voltage Flatness – Generate 0.3 mV to 3.5 V (0.3 to 1.1) mV (0.3 to 3) mV 3 mV to 3.5 V	(10 to 30) Hz 30 Hz to 120 kHz 120 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz 120 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz 120 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.27 % of reading 0.14 % of reading 0.46 % of reading 0.62 % of reading 0.80 % of reading 2.4 % of reading 0.22 % of reading 0.37 % of reading 0.55 % of reading 1.4 % of reading 0.12 % of reading 0.21 % of reading 0.38 % of reading 0.86 % of reading	Fluke 5700A or 5700A-03 (referenced to 1 kHz)
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 1395A's thermal voltage converters

Parameter/Range	Frequency	CMC ^{2,4,5} (±)	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
Capacitance – Generate Direct Measure (1, 10) pF (100, 1000) pF (0.01, 0.1, 1) μF Algorithmic Derivation 1 pF (10, 100) pF 1000 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 1 MHz 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 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

Parameter/Range	Frequency	CMC ^{2,4,5} (±)	Comments
Capacitance Generate – (cont)			
Substitution Method (0.01, 0.1, 1) μF	120 Hz to 10 kHz	0.025 % of reading 0.04 % of reading	16380A/16380C standard air capacitor set, BNC 4 terminal pair
(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 300) Hz (10 to 150) Hz	0.4 % of reading 0.4 % of reading 0.4 % of reading 0.4 % of reading 0.4 % of reading	Fluke 5720A

II. Electrical – RF/Microwave

Parameter/Equipment/Range	CMC ^{2,9} (±)	Comments
Amplitude Modulation – Measure ⁸		HP 8902A measuring receiver:
(0.15 to 10) MHz (5% to < 10%) AM (10% to 99%) AM	0.025AM + 0.03 % 0.025AM + 0.14 %	rate: 50 Hz to 10 kHz, depth: 5% to 99%
(5% to < 10%) AM (10% to 99%) AM	0.038AM + 0.03 % 0.038AM + 0.13 %	rate: 20 Hz to 10 kHz, depth: to 99%
(10 to 1300) MHz (5% to <10%) AM (10% to 99%) AM	0.012AM + 0.033 % 0.012AM + 0.17 %	rate: 50 Hz to 10 kHz, depth: 5% to 99%
(5% to <10%) AM (10% to 99%) AM	0.038AM + 0.030 % 0.037AM + 0.16 %	rate: 20 Hz to 10 kHz, depth: to 99%
1300 MHz to 26.5 GHz (5% to <10%) AM (10% to 99%) AM	0.019AM + 0.029 % 0.019AM + 0.14 %	rate: 50 Hz to 10 kHz, depth: 5% to 99%
10 MHz to 26.5 GHz (5% to <10%) AM (10% to 99%) AM	0.038AM + 0.030 % 0.038AM + 0.11 %	rate: 20 Hz to 10 kHz, depth: to 99%

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Parameter/Equipment/Range	CMC ^{2,9} (±)	Comments
<p>Frequency Modulation – Measure⁹</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>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>0.024FM + 2.6 Hz Pk 0.024FM + 10 Hz Pk</p> <p>0.012FM + 2.6 Hz Pk 0.012FM + 12 Hz Pk 0.012FM + 110 Hz Pk</p> <p>0.059FM + 2.8 Hz Pk 0.059FM + 13 Hz Pk 0.059FM + 110 Hz Pk</p> <p>0.012FM + 2.4 Hz Pk 0.012FM + 12 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>HP 8902A 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> <p>rate: 50 Hz to 100 kHz, ≤400 kHz peak</p>

Parameter/Equipment/Range	CMC ^{2,9} (±)	Comments
<p>Frequency Modulation – Measure (cont)⁹</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>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>0.045FM + 62 Hz Pk 0.059FM + 16 Hz Pk 0.059FM + 120 Hz Pk</p>	<p>HP 8902A measuring receiver: 11793A DownConverter, gen.ext L.O.</p> <p>rate: 20 Hz to 200 kHz, ≤400 kHz peak</p> <p>rate: 20 Hz to 200 kHz, ≤400 kHz peak</p>

Parameter/Range	Frequency	CMC ² (±)	Comments
<p>Digital Modulation – Measure</p> <p>Carrier: 2 MHz to 2.65 GHz</p> <p>Error Vector Magnitude for Modulation Types: MSK, GMSK, BPSK, DQPSK, π/4DQPSK, 8PSK, 16QAM and 32QAM, QPSK</p>	<p>Mod Frequency Span: (1 to 100) kHz (0.1 to 1) MHz 1 MHz to 2.65 GHz</p>	<p>0.3 % rms 0.5 % rms 0.93 % rms</p>	<p>HP 89441A vector signal analyzer</p>

Parameter/Range	Frequency	CMC ² (±)	Comments
<p>Digital Modulation – Measure (cont.)</p> <p>Carrier: 2 MHz to 2.65 GHz</p> <p>Phase Error for Modulation Types: MSK, GMSK, BPSK, DQPSK, n/4DQPSK, 8PSK, 16QAM and 32QAM, QPSK</p> <p>Error Vector Magnitude for FSK Modulation</p>	<p>Mod Frequency Span: (1 to 100) kHz (0.1 to 1) MHz 1 MHz to 2.65 GHz</p> <p>Mod Frequency: 3.2 kHz 1.152 kHz</p>	<p>0.18° rms 0.34° rms 0.57° rms</p> <p>0.52 % rms 1.5 % rms</p>	<p>HP 89441A vector signal analyzer</p>
<p>RF Absolute Power – Measure⁶</p> <p>1 mW, Type-N(f), 50 Ω</p> <p>(+20 to -30) dBm, 75 Ω</p> <p>(+20 to -30) dBm, 50 Ω</p> <p>(-20 to -70) dBm, 50 Ω</p>	<p>50 MHz</p> <p>(100 to 600) kHz SWR ≤ 1.8:1 600 kHz to 2 GHz SWR ≤ 1.18:1</p> <p>(100 to 300) kHz SWR ≤ 1.6:1 300 kHz to 1 MHz SWR ≤ 1.2:1 1 MHz to 2 GHz SWR ≤ 1.1:1 (2 to 4.2) GHz SWR ≤ 1.3:1</p> <p>(10 to 30) MHz SWR ≤ 1.4:1 30 MHz to 4 GHz SWR ≤ 1.15:1 (4 to 10) GHz SWR ≤ 1.21:1 (10 to 15) GHz SWR ≤ 1.3:1 (15 to 18) GHz SWR ≤ 1.35:1</p>	<p>0.015 dB (3.4 μW)</p> <p>0.057 dB 0.059 dB</p> <p>0.05 dB 0.049 dB 0.051 dB 0.050 dB</p> <p>0.074 dB 0.074 dB 0.077 dB 0.10 dB 0.11 dB</p>	<p>HP 432A w/ HP 478A-H76</p> <p>HP 436A or HP 438A w/ HP 8483A, Type-N(m)</p> <p>HP 436A or HP 438A w/ HP 8482A, Type-N(m)</p> <p>HP 436A or HP 438A w/ HP 8481D, Type-N(m)</p>

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

Parameter/Range	Frequency	CMC ² (±)	Comments
Tuned RF Power – Absolute – Measure ⁷ (≤ +10 to ≥ -22) dBm (< -22 to ≥ -42) dBm (< -42 to ≥ -50) dBm (< -50 to ≥ -60) dBm (< -60 to ≥ -72) dBm (< -72 to ≥ -80) dBm (< -80 to ≥ -92) dBm (< -92 to ≥ -102) dBm (< -102 to ≥ -110) dBm (< -110 to ≥ -120) dBm (< -120 to ≥ -127) dBm	2.5 MHz to 26.5 GHz	0.17 dB 0.18 dB 0.20 dB 0.21 dB 0.22 dB 0.23 dB 0.24 dB 0.27 dB 0.28 dB 0.31 dB 0.34 dB	HP 8902A with HP 11722A or with HP 11792A and HP 11793A
Tuned RF Power – Relative – Measure (≤ +10 to ≥ +2) dBm (< +2 to ≥ -12) dBm (< -12 to ≥ -22) dBm (< -22 to ≥ -31) dBm (< -31 to ≥ -40) dBm (< -40 to ≥ -50) dBm (< -50 to ≥ -61) dBm (< -61 to ≥ -71) dBm (< -71 to ≥ -80) dBm (< -80 to ≥ -90) dBm (< -90 to ≥ -100) dBm (< -100 to ≥ -110) dBm (< -110 to ≥ -120) dBm (< -120 to ≥ -127) dBm	2.5 MHz to 26.5 GHz	0.081 dB 0.071 dB 0.081 dB 0.088 dB 0.095 dB 0.12 dB 0.15 dB 0.16 dB 0.17 dB 0.19 dB 0.22 dB 0.23 dB 0.27 dB 0.30 dB	HP 8902A with HP 11722A or with HP 11792A and HP 11793A
RF Absolute Power – Generate ⁶ Into 50 Ω (10 to 3) V p-p 2.99 V to 1 mV p-p	0.001 Hz to 100 kHz SWR 1.2:1 0.001 Hz to 100 kHz SWR 1.2:1	0.12 dB 0.23 dB	HP 3325A/B with BNC(f)

Parameter/Range	Frequency	CMC ² (±)	Comments
RF Absolute Power – Generate ⁶ (cont.)			
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	
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	

Parameter/Range	Frequency	CMC ² (±)	Comments
RF Absolute Power – Generate 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:	1.5 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	1.0 dB	
Into 50 Ω			
> -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	CMC ² (±)	Comments
Attenuation – Generate			
Coaxial, 1 dB Step (0 to 11) dB			
0 dB	50 MHz to 2 GHz (2 to 4) GHz	0.026 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	
Coaxial, 1 dB Step (0 to 11) dB			
6 dB	50 MHz to 2 GHz (2 to 4) GHz	0.029 0.030	HP 8494G w/ Type-N(f)
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	CMC ² (±)	Comments
Attenuation – Generate (cont.)			
Coaxial, 10 dB Step 0 dB	50 MHz to 2 GHz	0.026	HP 8494G w/ Type-N(f)
	(2 to 4) GHz	0.029	
10 dB	50 MHz to 2 GHz	0.031	
	(2 to 4) GHz	0.030	
20 dB	50 MHz to 2 GHz	0.032	
	(2 to 4) GHz	0.032	
30 dB	50 MHz to 2 GHz	0.034	
	(2 to 4) GHz	0.035	
40 dB	50 MHz to 2 GHz	0.041	
	(2 to 4) GHz	0.045	
50 dB	50 MHz to 2 GHz	0.052	
	(2 to 4) GHz	0.054	
60 dB	50 MHz to 2 GHz	0.052	
	(2 to 4) GHz	0.055	
70 dB	50 MHz to 2 GHz	0.054	
	(2 to 4) GHz	0.057	
Coaxial, 10 dB Step			
80 dB	50 MHz to 2 GHz	0.059	HP 8496G w/ Type-N(f)
	(2 to 4) GHz	0.064	
90 dB	50 MHz to 2 GHz	0.066	
	(2 to 4) GHz	0.071	
100 dB	50 MHz to 2 GHz	0.067	
	(2 to 4) GHz	0.071	
110 dB	50 MHz to 2 GHz	0.074	
	(2 to 4) GHz	0.073	

Parameter/Range	Frequency	CMC ² (±)	Comments
Attenuation – Generate (cont.)			
Coaxial, Fixed			
3 dB	DC to 2 GHz, SWR < 1.25:1	0.028	HP 8496G w/ Type-N(f)
	(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	
Coaxial, Fixed			
20 dB	DC to 2 GHz, SWR < 1.5:1	0.032	HP 8491A/B Type-N
	(2 to 4) GHz, SWR < 1.5:1	0.032	
	(4 to 18) GHz, SWR < 1.5:1	0.052	

Parameter/Range	CMC ² (±)	Comments
Reflection S₁₁/ S₂₂ – Measure		
30 kHz to 1.3 GHz (0 to 1.0) lin	(± 0.0044 to ±0.022) lin (± 180 to ±1.3) deg	Network analyzer HP8753ES Type-N precision cal kit 85032B APC 7mm precision cal kit HP85031B
300 kHz to 1.3 GHz (0 to 1.0) lin	(± 0.0071 to ±0.035) lin (± 180 to ±2.0) deg	
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 ±1.504) deg	
(3 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 to 3) GHz (0 to 1.0) lin	(± 0.0036 to ±0.011) 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	
Transmission S₁₂/ S₂₁ – Measure		
30 kHz to 1.3 GHz (0 to 20) dB	(± 0.041 to ± 0.063) dB (± 0.42 to ± 0.46) deg	Network analyzer 8753ES Type-N precision cal kit 85032B
(20 to 40) dB	(± 0.063 to ± 0.088) dB (± 0.46 to ± 0.62) deg	
(40 to 60) dB	(± 0.088 to ± 0.29) dB (± 0.62 to ± 2.0) deg	
(1.3 to 3) GHz (0 to 20) dB	(± 0.056 to ± 0.076) dB (± 0.79 to ± 1.3) deg	
(20 to 40) dB	(± 0.076 to ± 0.11) dB (± 1.3 to ± 1.4) deg	
(40 to 60) dB	(± 0.11 to ± 0.32) dB (± 1.4 to ± 2.2) deg	

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Parameter/Range	CMC ² (±)	Comments
Transmission S ₁₂ / S ₂₁ – Measure (3 to 6) GHz (0 to 20) dB (20 to 40) dB (40 to 60) dB	 (± 0.094 to ± 0.13) dB (± 1.2 to ± 1.6) deg (± 0.13 to ± 0.16) dB (± 1.6 to ± 1.7) deg (± 0.16 to ± 0.51) dB (± 1.7 to ± 3.6) deg	Network analyzer 8753ES Type-N precision cal kit 85032B

III. Time and Frequency

Parameter/Equipment	Range	CMC ² (±)	Comments
Frequency – Generate	5 MHz, 10 MHz	10 pHz/Hz	Datum 8040
Frequency – Measure	1 Hz to 40 GHz	50 pHz/Hz	HP 53132A HP 5352B

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 ($t_{cal} \pm 5 \text{ }^\circ\text{C}$) 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. 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 ± 5 °C and an auto-calibration (ACAL) was performed within the previous 24 hours (± 1 °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 CMC 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 CMC's 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 CMC's 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 *AM* is the amplitude modulation and *FM* is the frequency modulation.



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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, 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 16th day of October 2009.





Peter M. Meyer

President & CEO
For the Accreditation Council
Certificate Number 2863.01
Valid to November 30, 2011
Revised August 3, 2010

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