



The American Association for Laboratory Accreditation

World Class Accreditation

Accredited Laboratory

A2LA has accredited

ELECTRO RENT CORPORATION

Van Nuys, 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 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 10th day of August 2009.





President & CEO

For the Accreditation Council
Certificate Number 2562.01
Valid to June 30, 2011

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

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CALIBRATION

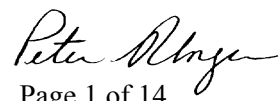
Valid To: June 30, 2011

Certificate Number: 2562.01

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, 8, 11} (±)	Comments
DC Voltage – Generate and Measure			
Fixed Points	10 V	1.7 µV/V	Zener Voltage Standard
	0.1 V	17 µV/V	Zener, 752A Ratio Divider
	1 V	2.5 µV/V	
	10 V	2.6 µV/V	
	100 V	2.1 µV/V	
	1000 V	2.1 µV/V	
Generate	(0 to 220) mV	13 µV/V + 1.2 µV	Fluke 5720A
	(0.22 to 2.2) V	7.3 µV/V + 2.7 µV	
	(2.2 to 11) V	5 µV/V + 8.3 µV	
	(11 to 22) V	5 µV/V + 11 µV	
	(22 to 220) V	6.9 µV/V + 0.18 mV	
	(220 to 1000) V	8.5 µV/V + 1.4 mV	
Measure	(0 to 100) mV	9 µV/V + 0.6 µV	3458A Opt 2 ³
	(0.1 to 1) V	9 µV/V + 0.6 µV	
	(1 to 10) V	5 µV/V + 0.9 µV	
	(10 to 100) V	6 µV/V + 52 µV	
	(100 to 1000) V	6 µV/V + 10 mV*	*See footnote 10
	(10 to 100) kV	570 V + 0.6R	HVA100 34401A



Parameter/Range	Frequency	CMC ^{2,8} (±)	Comments
AC Voltage – Generate and Measure			
10 mV	(10 to 20) Hz	0.04 %	Fluke 5790A, 5720A
	(20 to 40) Hz	0.033 %	
	40 Hz to 20 kHz	0.02 %	
	(20 to 50) kHz	0.032 %	
	(50 to 100) kHz	0.045 %	
	(100 to 300) kHz	0.097 %	
	(300 to 500) kHz	0.14 %	
(0.5 to 1) MHz	0.2 %		
20 mV	(10 to 20) Hz	0.03 %	
	(20 to 40) Hz	0.021 %	
	40 Hz to 20 kHz	0.014 %	
	(20 to 50) kHz	0.025 %	
	(50 to 100) kHz	0.035 %	
	(100 to 300) kHz	0.081 %	
	(300 to 500) kHz	0.1 %	
(0.5 to 1) MHz	0.17 %		
100 mV	(10 to 20) Hz	0.018 %	
	(20 to 40) Hz	81 μV/V	
	40 Hz to 20 kHz	46 μV/V	
	(20 to 50) kHz	71 μV/V	
	(50 to 100) kHz	0.015 %	
	(100 to 300) kHz	0.023 %	
	(300 to 500) kHz	0.038 %	
(0.5 to 1) MHz	0.087 %		
200 mV	(10 to 20) Hz	0.018 %	
	(20 to 40) Hz	76 μV/V	
	40 Hz to 20 kHz	40 μV/V	
	(20 to 50) kHz	64 μV/V	
	(50 to 100) kHz	0.014 %	
	(100 to 300) kHz	0.025 %	
	(300 to 500) kHz	0.035 %	
(0.5 to 1) MHz	0.084 %		
1 V	(10 to 20) Hz	0.018 %	
	(20 to 40) Hz	61 μV/V	
	40 Hz to 20 kHz	22 μV/V	
	(20 to 50) kHz	37 μV/V	
	(50 to 100) kHz	58 μV/V	
	(100 to 300) kHz	0.014 %	
	(300 to 500) kHz	0.022 %	
(0.5 to 1) MHz	0.074 %		

Parameter/Range	Frequency	CMC ^{2, 8} (±)	Comments
AC Voltage – Generate and Measure (cont)			
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 (0.5 to 1) MHz	0.016 % 56 µV/V 21 µV/V 37 µV/V 57 µV/V 0.015 % 0.022 % 0.074 %	Fluke 5790A, 5720A
10 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 (0.5 to 1) MHz	0.016 % 56 µV/V 24 µV/V 39 µV/V 64 µV/V 0.017 % 0.032 % 0.096 %	
20 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 (0.5 to 1) MHz	0.016 % 56 µV/V 24 µV/V 39 µV/V 64 µV/V 0.017 % 0.032 % 0.096 %	
44 V	(300 to 500) kHz	0.032 %	
60 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	0.016 % 60 µV/V 26 µV/V 45 µV/V 73 µV/V 0.016 %	
100 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.016 % 58 µV/V 31 µV/V 56 µV/V 78 µV/V	

Parameter/Range	Frequency	CMC ^{2, 8, 11} (\pm)	Comments
AC Voltage – Generate and Measure (cont)			
200 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.017 % 63 μ V/V 25 μ V/V 54 μ V/V 76 μ V/V	Fluke 5790A, 5720A
300 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.016 % 77 μ V/V 33 μ V/V 0.011 % 0.039 %	
600 V	50 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	33 μ V/V 0.011 % 0.039 %	
1000 V	50Hz to 1 kHz	33 μ V/V	
AC Voltage – Measure (10 to 100) kV	60 Hz	300 V +0.6R	HVA100, 34401A

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
DC Current – Generate and Measure			
Fixed Points	100 μ A 1 mA 10 mA 20 mA 100 mA 200 mA 1 A 10 A	1.9 nA 14 nA 0.14 μ A 0.28 μ A 1.4 μ A 2.8 μ A 20 μ A 550 μ A	Guildline 9334A ⁴ Guildline 9330 ⁴ Fluke Y5020 ⁴
Generate	(0 to 220) μ A (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2A	40 μ A/A + 5.5 nA 32 μ A/A + 6.2 nA 32 μ A/A + 39 nA 39 μ A/A + 0.62 μ A 70 μ A/A + 12 μ A	Fluke 5700A/ep
Measure	(10 to 100) μ A (1 to 10) mA (10 to 100) mA 100 mA to 1A	55 μ A/A + 0.2 nA 55 μ A/A + 0.1 μ A 0.012 % rdg + 1 μ A 0.014 % rdg + 12 μ A	AT 3458A

Parameter/Equipment	Range	CMC ² (±)	Comments
AC Voltage Bandwidth – Generate and Measure	50 kHz to 550 MHz 50 kHz to 3.2 GHz 50 MHz to 26 GHz	4.5 % 5.5 % 7 % + <i>M</i>	9500B 9500B/3200 E8257D 11667 8487 E4418 <i>M</i> = mismatch error

Parameter/Range	Frequency	CMC ² (±)	Comments
AC Current – Measure			
10 mA	10 Hz 20 Hz 40 Hz (1,5,10) kHz	23 µA 17 µA 1.6 µA 1.6 µA	Thermal current transfer
20 mA	10 Hz 20 Hz 40 Hz (1,5,10) kHz	46 µA 34 µA 3.2 µA 3.2 µA	
100 mA	10 Hz 20 Hz 40 Hz (1,5,10) kHz	23 µA 17 µA 16 µA 16 µA	
200 mA	10 Hz 20 Hz 40 Hz (1,5,10) kHz	46 µA 34 µA 32 µA 32 µA	
1 A	40 Hz (1,5,10) kHz	170 µA 170 µA	
2 A	40 Hz (1,5,10) kHz	330 µA 330 µA	
10 A	40 Hz (1,5,10) kHz	1.8 mA 1.8 mA	

Parameter/Range	Frequency	CMC ^{2,8} (±)	Comments
AC Current – Generate			Fluke 5700A/EP
(0 to 220) µA	(10 to 20) Hz (20 to 45) Hz (45 to 1000) Hz (1 to 1) kHz (5 to 10) kHz	0.025 % + 0.022 µA 0.016 % + 0.016 µA 0.012 % + 0.013 µA 0.028 % + 0.034 µA 0.11 % + 0.083 µA	
(0.22 to 2.2) mA	(10 to 20) Hz (20 to 45) Hz (45 to 1000) Hz (1 to 5) kHz (5 to 10) kHz	0.027 % + 0.16 µA 0.016 % + 0.11 µA 0.012 % + 0.1 µA 0.02 % + 0.18 µA 0.11 % + 0.67 µA	
(2.2 to 22) mA	(10 to 20) Hz (20 to 45) Hz (45 to 1000) Hz (1 to 5) kHz (5 to 10) kHz	0.025 % + 2.4 µA 0.016 % + 1.4 µA 0.012 % + 1 µA 0.02 % + 1.4 µA 0.11 % + 5.3 µA	
(22 to 220) mA	(10 to 20) Hz (20 to 45) Hz (45 to 1000) Hz (1 to 5) kHz (5 to 10) kHz	0.025 % + 24 µA 0.016 % + 13 µA 0.012 % + 9 µA 0.02 % + 14 µA 0.11 % + 47 µA	
(0.22 to 2.2) A	(10 to 20) Hz (20 to 45) Hz (45 to 1000) Hz (1 to 5) kHz (5 to 10) kHz	0.026 % + 145 µA 0.026 % + 145 µA 0.026 % + 145 µA 0.045 % + 160 µA 0.7 % + 900 µA	
(100 to 1000) A*	(45 to 65) Hz	0.24 % + 0.02 A	5520A 34401A * Coil ampere turns

Parameter/Equipment	Range	CMC ² (±)	Comments
Resistance – Generate and Measure			
Fixed Points ⁴	1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ	3.8 µΩ/Ω 3.2 µΩ/Ω 3.6 µΩ/Ω 3.6 µΩ/Ω 3.1 µΩ	Guildline 9334A

Parameter/Equipment	Range	CMC ² (±)	Comments
Resistance –Generate and Measure (cont)			
Fixed Points ⁴	100 kΩ 1 MΩ 10 MΩ 100 MΩ	5.4 μΩ/Ω 7.5 μΩ/Ω 22 μΩ/Ω 67 μΩ/Ω	Guildline 9334A
Measure Only ⁵	(0.01 to 1) Ω (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω (1 to 10) kΩ (10 to 100) kΩ (100 to 1000) kΩ (1 to 10) MΩ (10 to 100) MΩ	580 μΩ/Ω + 80 μΩ* 15 μΩ/Ω + 80 μΩ * 14 μΩ/Ω + 800 μΩ 13 μΩ/Ω + 2.5 mΩ 13 μΩ/Ω + 25 mΩ 13 μΩ/Ω + 250 mΩ 13 μΩ/Ω + 6 Ω 44 μΩ/Ω + 130 Ω 0.036 % rdg + 1.4 kΩ	Agilent 3458A *See footnote 11

II. Electrical – RF & Microwave

Parameter/Range	Frequency	CMC ² (±)	Comments
Power Measure – Milliwatt Reference			
1 mW @ 50 Ω	50 MHz	0.4 % rdg	432A w/478AH76, 3458A
Power Measure ⁹			
(10 to 20) dBm	100 to 300 kHz SWR < 1.6:1	0.14 dB	Agilent 8482A-H84 with E4419B
	300 kHz to 1 MHz SWR < 1.2:1	0.14 dB	
	1 Mhz to 2 GHz SWR < 1.1:1	0.14 dB	
	2 to 4.2 GHz SWR < 1.3:1	0.14 dB	

Parameter/Equipment	Range	CMC ² (±)	Comments	
Power Measure ⁹ (cont) – (-20 to 10) dBm	100 to 300 kHz SWR < 1.6:1	0.058 dB	Agilent 8487A-H84 with E4419B	
	300 kHz to 1 MHz SWR < 1.2:1	0.053 dB		
	1 MHz to 2 GHz SWR < 1.1:1	0.055 dB		
	2 to 4.2 GHz SWR < 1.3:1	0.056 dB		
	(10 to 20) dBm	50 to 100 MHz SWR < 1.15:1		0.14 dB
		0.1 to 2 GHz SWR < 1.1:1		0.14 dB
		2 to 12.4 GHz SWR < 1.15:1		0.15 dB
		12.4 to 18 GHz SWR < 1.2:1		0.15 dB
		18 to 26.5 GHz SWR < 1.25:1		0.15 dB
	(-20 to 10) dBm	26.5 to 40 GHz SWR < 1.4:1		0.16 dB
		40 to 50 GHz SWR < 1.5:1		0.2 dB
		50 to 100 MHz SWR < 1.15:1		0.072 dB
0.1 to 2 GHz SWR < 1.1:1		0.072 dB		
2 to 12.4 GHz SWR < 1.15:1		0.076 dB		
12.4 to 18 GHz SWR < 1.2:1		0.078 dB		
18 to 26.5 GHz SWR < 1.25:1		0.09 dB		
26.5 to 40 GHz SWR < 1.4:1		0.11 dB		
40 to 50 GHz SWR < 1.5:1	0.16 dB			

Parameter/Equipment	Range	CMC ² (±)	Comments
Power Measure ⁹ (cont) – (-60 to -20) dBm	50 to 100 MHz SWR < 1.15:1 0.1 to 2 GHz SWR < 1.1:1 2 to 12.4 GHz SWR < 1.15:1 12.4 to 18 GHz SWR < 1.2:1 18 to 26.5 GHz SWR < 1.25:1 26.5 to 40 GHz SWR < 1.4:1 40 to 50 GHz SWR < 1.5:1	0.18 dB 0.18 dB 0.18 dB 0.19 dB 0.19 dB 0.2 dB 0.23 dB	Agilent 8487D with E4419B
Network Analyzer Dynamic Accuracy Test	5 dBm change	0.002 dB	Agilent 8482A with E4419B
Cal Factor & Effective Efficiency ⁶ @ 50 Ω Nominal 1 mW	(0.1 to 4200) MHz (4.2 to 12.4) GHz (12.4 to 15) GHz (15 to 26) GHz (26 to 40) GHz (40 to 50) GHz	1.3 % cal factor 1.8 % cal factor 2 % cal factor 3 % cal factor 3 % cal factor 5 % cal factor	RF power transfer & DC substitution

Parameter/Equipment	Range	CMC ² (±)	Comments
S-Parameters –			
S ₁₁₍₂₂₎ Measure – @ 50 Ω 2.4 mm 45 MHz to 2 GHz	(0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(0.019 to 0.028) lin (0.017 to 0.018) lin 0.017 lin	E8361A, 85056A
	(0.3 to 1) lin (0.01 to 0.3) lin	(3.5 to 1.6) deg (180 to 3.5) deg	
	(2 to 20) GHz (0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(0.023 to 0.034) lin (0.018 to 0.023) lin 0.018 lin	
	(0.3 to 1) lin (0.01 to 0.3) lin	(5 to 2) deg (180 to 5) deg	
	(20 to 40) GHz (0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(0.037 to 0.056) lin (0.03 to 0.037) lin 0.03 lin	
	(40 to 50) GHz (0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(0.044 to 0.07) lin (0.034 to 0.044) lin 0.034 lin	
S ₁₂₍₂₁₎ Measure – 2.4 mm 45 MHz to 26 GHz	(0.3 to 1) lin (0.01 to 0.3) lin	(11 to 4) deg (180 to 11) deg	
	(0 to -60) db	(0.08 to 0.6) db (0.5 to 5.8) deg	
S ₁₁₍₂₂₎ Measure – @ 50 Ω 3.5 mm 45 MHz to 2 GHz	(0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(0.01 to 0.022) lin (0.009 to 0.01) lin 0.009 lin	E8361A, 85052C
	(0.3 to 1) lin (0.01 to 0.3) lin	(2 to 1.3) deg (54 to 2) deg	

Parameter/Equipment	Range	CMC ² (±)	Comments
S-Parameters (cont) –			
S ₁₁₍₂₂₎ Measure – @ 50 Ω 3.5 mm (2 to 20) GHz (20 to 26) GHz	(0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(0.012 to 0.015) lin (0.008 to 0.013) lin 0.008 lin	E8361A, 85050C
	(0.3 to 1) lin (0.01 to 0.3) lin	(2.6 to 0.82) deg (0.0045 to 2.6) deg	
	(0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(0.013 to 0.017) lin (0.008 to 0.014) lin 0.009 lin	
	(0.3 to 1) lin (0.01 to 0.3) lin	(2.8 to 1) deg (53 to 2.8) deg	
S ₁₂₍₂₁₎ Measure – 3.5 mm 45 MHz to 26 GHz	(0 to -60) db	(0.05 to 0.27) db; (0.3 to 1.9) deg	
S ₁₁₍₂₂₎ Measure – @ 50 Ω 7 mm, Type N ⁶ 45 MHz to 2 GHz (2 to 18) GHz	(0.01 to 1) lin	(0.003 to 0.01) lin	
	(0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(1 to 0.6) deg (6 to 1) deg (16 to 6) deg	
	(0.01 to 1) lin	(0.002 to 0.007) lin	
	(0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(1.6 to 0.4) deg (5 to 1.6) deg (11 to 5) deg	
S ₁₂₍₂₁₎ Measure – 7 mm, Type N ⁶ 45 MHz to 18 GHz	(0 to -60) db	(0.05 to 0.27) db; (0.3 to 1.9) deg	

Parameter/Equipment	Range	CMC ² (±)	Comments
Pulse – Generate & Measure			
Transition Time	(20 to 2000) ps	5 ps + 0.02*T rdg	9500B
Generate Only			SD24/11801C
Transition Time	<20 ps	5 ps	T = transition time Tek 067-1338-00
RF Power – Measure			
Relative Level	100 kHz to 50 Ghz	0.012 db + 0.004 db/10db	E4448A/233
Insertion Loss	100 kHz to 50 Ghz	0.026 db + 0.004 db/10db + M	M = mismatch error
Amplitude Modulation – Measure			
200MHz to 3Ghz	(30 to 90) % ratio; 1 kHz rate	0.45 % AM	E4448A/233
0.010kHz to 50Ghz	5 % ratio; 50 Hz to 5 kHz rate	2.4 % AM	
	30 % ratio; 50 Hz to 5 kHz rate	1.2 % AM	
	99 % ratio; 50 Hz to 5 kHz rate	0.42 % AM	
	5 % ratio; (5 to 100) kHz rate	2.4 % AM	
	30 % ratio; (5 to 100) kHz rate	0.88 % AM	
	99 % ratio; (5 to 100) kHz rate	0.32 % AM	

Parameter/Equipment	Range	CMC ² (±)	Comments
Angular (Frequency) Modulation – Measure 200MHz to 20Ghz	(100 to 240) kHz peak deviation modulation index > 1	0.8 kHz	AT-E4448A AT-33250A AT-34401A DTM-CSiii
Angular (Phase) Modulation – Measure 200MHz to 20Ghz	(1 to 10) radian modulation index	0.77 % radian + 0.0025 radians	AT-E4448A DTM-CSiii

III. Thermodynamics

Parameter/Equipment	Range	CMC ² (±)	Comments
Temperature – Measure	20 °C to 30 °C	0.07 °C	Hart 5628/1502
Relative Humidity – Measure (-20 to 20) °C (20 to 30) °C (30 to 50) °C	(10 to 90) % RH	3.5 % RH 2.3 % RH 3.5 % RH	Veriteq SP 2000

IV. Time & Frequency

Parameter/Range	Frequency	CMC ² (±)	Comments
Frequency – Measure	5, 10 MHz 1 Hz to 120 MHz 250 kHz to 50 GHz	2.5 pHz/Hz 10 pHz/Hz 10 nHz/Hz + 0.1 Hz	NIST FMAS, GPS receiver (1 Hz Steps) E4448A/233 with CSIII lock

Parameter/Range	Frequency	CMC ² (±)	Comments
Frequency – Generate	10 MHz distribution	10 pHz/Hz	CSIII, 58503B distribution amplifiers
	1 Hz to 10 MHz	2 µHz/Hz	AT 33250
	250 kHz to 50 GHz	10 nHz/Hz	E8257D-550 with CSIII lock
Time Interval – Generate and Measure	1 ns to 10 s	0.92 ns + $TI \cdot 0.04 \mu\text{s/s}$	33250A/ 53132A/12 <i>TI</i> = Time Interval in seconds

¹ This laboratory does not normally offer commercial calibration services.

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 Agilent 3458A with Option 2, settings DCV, 100PLC, ACAL within prior 24 Hrs, 1 year cal cycle.

⁴ Transfer using Agilent 3458A

⁵ Agilent 3458A four wire ohms, ACAL within prior 24 Hrs, NPLC 100 < 100E6 Ohm > NPLC 10

⁶ Calibration Factor 100 kHz to 10 Mhz is effective efficiency only.

⁷ Measure and Generate is limited to below 5 kHz; Measure only above 5 kHz.

⁸ The measurands stated are generated with the Fluke 5700, 5720 and/or 5790 series of instruments. This capability is suitable for the calibration of the devices intended to measure the stated measurand in the ranges indicated. CMC is expressed as either a specific value that covers the full range or as a fraction of the reading plus a fixed floor specification.

⁹ The statement of CMC does not include the effects of mismatch error.

¹⁰ Add $12 \mu\text{V/V}$ times $(V_{\text{input}} / 1000)^2$ for voltage > 100 V

¹¹ Plus resolution contribution from unit under test.