THE AMERICAN ASSOCIATION FOR LABORATORY ACCREDITATION

ACCREDITED LABORATORY

A2LA has accredited

ELECTRO RENT CORP.

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 18 June 2005*).

Presented this 13th day of June 2007.

President
For the Accreditation Council
Certificate Number 2562.01
Valid to June 30, 2009

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, 2009 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 calibrations[1]:

I. Electrical – DC & Low Frequency

Parameter/Equipment	Range	Best Uncertainty[2, 8] (±)	Comments
DC Voltage – Generate and Measure			
Fixed Points	10 V	2.4 parts in 10^6	Zener Voltage Standard
	0.1 V	15 parts in 10^6	Zener, 752A Ratio Divider
	1 V	3.2 parts in 10^6	
	10 V	2.7 parts in 10^6	
	100 V	3 parts in 10^6	
	1000 V	3 parts in 10^6	
	(0 to 100) mV	6 µV/V + 1.3 µV	Fluke 5720A, 3458A Opt 2[3]
	(0.1 to 1) V	6 µV/V + 1.3 µV	
	(1 to 10) V	6 µV/V + 1.3 µV	
	(10 to 100) V	7 µV/V + 50 µV	
	(100 to 1000) V	19 µV/V+ 90 µV	

Parameter/Range	Frequency	Best Uncertainty[2, 8] (±)	Comments
AC Voltage – Generate and Measure			
10 mV	(10 to 20) Hz (20 to 40) Hz (40 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.033 % 0.025 % 0.019 % 0.032 % 0.044 % 0.094 % 0.14 % 0.20 %	Fluke 5790A, 5720A
20 mV	(10 to 20) Hz (20 to 40) Hz (40 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.025 % 0.016 % 0.011 % 0.018 % 0.030 % 0.055 % 0.083 % 0.12 %	
100 mV	(10 to 20) Hz (20 to 40) Hz (40 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.018 % 78 µV/V 42 µV/V 69 µV/V 0.015 % 0.023 % 0.036 % 0.084 %	
200 mV	(10 to 20) Hz (20 to 40) Hz (40 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.017 % 65 µV/V 32 µV/V 48 µV/V 71 µV/V 0.016 % 0.027 % 0.078 %	

Parameter/Range	Frequency	Best Uncertainty[2, 8] (±)	Comments
AC Voltage – Generate and Measure (cont)			
1 V	(10 to 20) Hz	0.016 %	Fluke 5790A, 5720A
	(20 to 40) Hz	52 µV/V	
	(40 to 20) kHz	20 µV/V	
	(20 to 50) kHz	36 µV/V	
	(50 to 100) kHz	55 µV/V	
	(100 to 300) kHz	0.013 %	
	(300 to 500) kHz	0.021 %	
	(0.5 to 1) MHz	0.070 %	
2 V	(10 to 20) Hz	0.016 %	
	(20 to 40) Hz	51 µV/V	
	(40 to 20) kHz	19 µV/V	
	(20 to 50) kHz	36 µV/V	
	(50 to 100) kHz	55 µV/V	
	(100 to 300) kHz	0.013 %	
	(300 to 500) kHz	0.021 %	
	(0.5 to 1) MHz	0.070 %	
10 V	(10 to 20) Hz	0.016 %	
	(20 to 40) Hz	52 µV/V	
	(40 to 20) kHz	22 µV/V	
	(20 to 50) kHz	38 µV/V	
	(50 to 100) kHz	63 µV/V	
	(100 to 300) kHz	0.015 %	
	(300 to 500) kHz	0.031 %	
	(0.5 to 1) MHz	0.093 %	
20 V	(10 to 20) Hz	0.016 %	
	(20 to 40) Hz	52 µV/V	
	(40 to 20) kHz	22 µV/V	
	(20 to 50) kHz	38 µV/V	
	(50 to 100) kHz	63 µV/V	
	(100 to 300) kHz	0.015 %	
	(300 to 500) kHz	0.031 %	
	(0.5 to 1) MHz	0.093 %	

Parameter/Range	Frequency	Best Uncertainty[2, 8] (±)	Comments
AC Voltage – Generate and Measure (cont)			
60 V	(10 to 20) Hz (20 to 40) Hz (40 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 % 53 µV/V 25 µV/V 45 µV/V 73 µV/V 0.016 % 0.032 % 0.093 %	Fluke 5790A, 5720A
100 V	(10 to 20) Hz (20 to 40) Hz (40 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz	0.016 % 53 µV/V 25 µV/V 54 µV/V 76 µV/V 0.017 % 0.039 %	
200 V	(10 to 20) Hz (20 to 40) Hz (40 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz	0.016 % 53 µV/V 25 µV/V 54 µV/V 76 µV/V 0.017 % 0.039 %	
300 V	(10 to 20) Hz (20 to 40) Hz (40 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.016 % 77 µV/V 32 µV/V 0.011 % 0.039 %	
600 V	(10 to 20) Hz (20 to 40) Hz (40 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.016 % 77 µV/V 32 µV/V 0.011 % 0.039 %	
1000 V	(10 to 20) Hz (20 to 40) Hz (40 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.016 % 77 µV/V 30 µV/V 0.011% 0.039 %	

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
DC Current – Generate and Measure			
Fixed Points	100 µA 1 mA (10, 20) mA (100, 200) mA 1 A 10 A	0.012 % rdg 14 µA/A 11 µA/A 11 µA/A 30 µA/A 45 µA/A	Guildline 9334A[4] Guildline 9330[4] Fluke Y5020[4]
	(10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA 100 mA to 1A	50 µA/A + 0.2 nA 50 µA/A + 1 nA 50 µA/A + 0.1 µA 0.012 % rdg + 1 µA 0.014 % rdg + 15 µA	AT 3458A Fluke 5720A
Bandwidth – Generate	50 kHz to 550 MHz 50 kHz to 3.2 GHz 50 kHz to 6 GHz 50 MHz to 26 GHz	4.1 % rdg 5.1 % rdg 6.5 % rdg 5.8 % rdg + *M*	9500B 9500B/3200 9560 E8257D 11667 8487 E4418 *M* = mismatch error

Parameter/Range	Frequency	Best Uncertainty[2] (±)	Comments
AC Current – Generate and Measure			
10 mA	(0.4 to 5) kHz (5 to 10) kHz	0.018 % rdg 0.036 % rdg	Thermal current transfer
20 mA	(0.4 to 5) kHz (5 to 10) kHz	0.018 % rdg 0.036 % rdg	
100 mA	(0.4 to 5) kHz (5 to 10) kHz	0.018 % rdg 0.036 % rdg	
200 mA	(0.4 to 5) kHz (5 to 10) kHz	0.018 % rdg 0.036 % rdg	
1 A	(0.4 to 5) kHz (5 to 10) kHz	0.018 % rdg 0.065 % rdg	
2 A	(0.4 to 5) kHz (5 to 10) kHz	0.018 % rdg 0.065 % rdg	
10 A	(0.4 to 5) kHz (5 to 10) kHz	0.019 % rdg 0.024 % rdg	

Parameter/Range	Frequency	Best Uncertainty[2, 8] (±)	Comments
AC Current – Generate and Measure (cont)			
(0 to 100) µA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 1) kHz	0.27 % + 0.02 µA 0.10 % + 0.02 µA 0.040 % + 0.02 µA 0.040 % + 0.02 µA	Fluke 5700A AT 3458A
(0.1 to 1) mA[7]	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 5) kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.27 % + 0.14 µA 0.10 % + 0.14 µA 0.040 % + 0.14 µA 0.020 % + 0.14 µA 0.040 % + 0.14 µA 0.27 % + 0.27 µA 0.37 % + 1 µA	Fluke 5720A AT 3458A AT 3458A
(1 to 10) mA[7]	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 5) kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.27 % + 1.4 µA 0.10 % + 1.4 µA 0.040 % + 1.4 µA 0.020 % + 1.4 µA 0.040 % + 1.4 µA 0.27 % + 2.7 µA 0.37 % + 10 µA	Fluke 5720A AT 3458A AT 3458A
(10 to 100) mA[7]	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 5) kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.27 % + 14 µA 0.10 % + 14 µA 0.040 % + 14 µA 0.020 % + 14 µA 0.040 % + 14 µA 0.27 % + 27 µA 0.37 % + 100 µA	Fluke 5720A AT 3458A AT 3458A
(0.1 to 1) A[7]	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 5) kHz (5 to 20) kHz	0.11 % + 140 µA 0.040 % + 140 µA 0.067 % + 140 µA 0.20 % + 140 µA 0.67 % + 270 µA	Fluke 5720A AT 3458A AT 3458A

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Resistance –Generate and Measure			
Fixed Points[4]	1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ	3.2 µΩ/Ω 3.0 µΩ/Ω 3.2 µΩ/Ω 3.2 µΩ/Ω 2.9 µΩ/Ω	Guildline 9334A

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Resistance –Generate and Measure (cont)			
Fixed Points[4]	100 kΩ 1 MΩ 10 MΩ 100 MΩ	5.3 μΩ/Ω 7.5 μΩ/Ω 25 μΩ/Ω 67 μΩ/Ω	Guildline 9334A
Measure Only[5]	(0.01 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	14 μΩ/Ω + 80 μΩ 12 μΩ/Ω + 800 μΩ 11 μΩ/Ω + 2.5 mΩ 11 μΩ/Ω + 25 mΩ 11 μΩ/Ω + 250 mΩ 11 μΩ/Ω + 6 Ω 44 μΩ/Ω + 130 Ω 0.036 % rdg + 1.4 kΩ	Agilent 3458A

II. Electrical – RF & Microwave

Parameter/Range	Frequency	Best Uncertainty[2] (±)	Comments
Power Measure – Milliwatt Reference[9]			
1 mW @ 50 Ω	50 MHz	0.4 % rdg	WG EPM-1 TK-10 or 432A w/478AH76, 3458A
(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	
(-20 to 10) dBm	100 to 300 kHz SWR < 1.6:1	0.058 dB	
	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	

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Power Measure – Milliwatt Reference (cont)[9]			
(10 to 20) dBm	50 to 100 MHz SWR < 1.15:1	0.14 dB	Agilent 8487A-H84 with E4419B
	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	
	26.5 to 40 GHz SWR < 1.4:1	0.16 dB	
	40 to 50 GHz SWR < 1.5:1	0.20 dB	
(-20 to 10) dBm	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	0.090 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	Best Uncertainty[2] (±)	Comments
Power Measure – Milliwatt Reference (cont)[9] (-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 0.20 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, @ 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 % rdg 1.8 % rdg 2 % rdg 3 % rdg 3 % rdg 5 % rdg	RF power transfer & DC substitution

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
S_{11} Measure – @ 50 Ω			
2.4 mm			
45 MHz to 2 GHz	(0.6 to 1) lin	0.020 lin, 1.3 deg	E8361A, 85056A
	(0.3 to 0.6) lin	0.014 lin, 2.0 deg	
	(0.1 to 0.3) lin	0.011 lin, 5.2 deg	
	(0.03 to 0.1) lin	0.009 lin, 17deg	
	(0.01 to 0.03) lin	0.018 lin, 57 deg	
	(0.001 to 0.01) lin	0.018 lin, 180 deg	
(2 to 20) GHz	(0.6 to 1) lin	0.026 lin, 1.6 deg	
	(0.3 to 0.6) lin	0.017 lin, 2.2 deg	
	(0.1 to 0.3) lin	0.012 lin, 5.4 deg	
	(0.03 to 0.1) lin	0.010 lin, 17 deg	
	(0.01 to 0.03) lin	0.014 lin, 59 deg	
	(0.001 to 0.01) lin	0.014 lin, 180 deg	
(20 to 40) GHz	(0.6 to 1) lin	0.043 lin, 2.7 deg	E8361A, 85056A
	(0.3 to 0.6) lin	0.028 lin, 3.8 deg	
	(0.1 to 0.3) lin	0.019 lin, 8.8 deg	
	(0.03 to 0.1) lin	0.015 lin, 28 deg	
	(0.01 to 0.03) lin	0.009 lin, 180 deg	
	(0.001 to 0.01) lin	0.009 lin, 180 deg	
(40 to 50) GHz	(0.6 to 1) lin	0.053 lin, 3.3 deg	
	(0.3 to 0.6) lin	0.034 lin, 4.6 deg	
	(0.1 to 0.3) lin	0.024 lin, 11 deg	
	(0.03 to 0.1) lin	0.019 lin, 36 deg	
	(0.01 to 0.03) lin	0.009 lin, 180 deg	
	(0.001 to 0.01) lin	0.009 lin, 180 deg	
3.5 mm			
45 MHz to 2 GHz	(0.6 to 1) lin	0.018 lin, 1.0 deg	E8361A, 85052C
	(0.3 to 0.6) lin	0.010 lin, 1.3 deg	
	(0.1 to 0.3) lin	0.007 lin, 2.8 deg	
	(0.03 to 0.1) lin	0.005 lin, 8.5 deg	
	(0.01 to 0.03) lin	0.005 lin, 26 deg	
	(0.001 to 0.01) lin	0.005 lin, 180 deg	
(2 to 20) GHz	(0.6 to 1) lin	0.012 lin, 0.8 deg	
	(0.3 to 0.6) lin	0.009 lin, 1.2 deg	
	(0.1 to 0.3) lin	0.006 lin, 2.7 deg	
	(0.03 to 0.1) lin	0.005 lin, 7.7 deg	
	(0.01 to 0.03) lin	0.004 lin, 23 deg	
	(0.001 to 0.01) lin	0.004 lin, 180 deg	
(20 to 26) GHz	(0.6 to 1) lin	0.013 lin, 1.0 deg	
	(0.3 to 0.6) lin	0.010 lin, 1.4 deg	
	(0.1 to 0.3) lin	0.007 lin, 3.0 deg	
	(0.03 to 0.1) lin	0.006 lin, 8.6 deg	
	(0.01 to 0.03) lin	0.005 lin, 26 deg	
	(0.001 to 0.01) lin	0.005 lin, 180 deg	

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
S_{11} Measure – @ 50 Ω (cont)			
7 mm, Type N[6] 45 MHz to 2 GHz	(0.6 to 1) lin (0.3 to 0.6) lin (0.1 to 0.3) lin (0.03 to 0.1) lin (0.01 to 0.03) lin (0.001 to 0.01) lin	0.010 lin, 0.6 deg 0.007 lin, 0.9 deg 0.005 lin, 2.0 deg 0.004 lin, 5.7 deg 0.003 lin, 17 deg 0.003 lin, 180 deg	E8361A, 85050C
(2 to 18) GHz	(0.6 to 1) lin (0.3 to 0.6) lin (0.1 to 0.3) lin (0.03 to 0.1) lin (0.01 to 0.03) lin (0.001 to 0.01) lin	0.008 lin, 0.6 deg 0.006 lin, 0.8 deg 0.004 lin, 1.4 deg 0.003 lin, 3.6 deg 0.002 lin, 9.7 deg 0.002 lin, 180 deg	
Pulse – Generate & Measure			
Transition Time	(20 to 2000) ps	5 ps + 0.02**T* rdg	9500b 9560 1543XA filters SD24/11801C *T* = Transition Time
Generate Only			
Transition Time	<20 ps	5 ps	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

III. Time & Frequency

Parameter/Range	Frequency	Best Uncertainty[2] (±)	Comments
Frequency – Measure	5, 10 MHz 1 Hz to 120 MHz	2.5 parts in 10^{12} 1 part in 10^{11}	NIST FMAS, GPS receiver (1 Hz Steps)
	250 kHz to 50 GHz	1 parts in 10^{8} + 0.1 Hz	E4448A/233 with CSIII lock

Parameter/Range	Frequency	Best Uncertainty[2] (±)	Comments
Frequency – Generate	10 MHz Distribution 1 Hz to 10 MHz 250 kHz to 50 GHz	1 part in 10^{11} 2 parts in 10^{6} 1 parts in 10^{8}	CSIII, 58503B distribution amplifiers AT 33250 E8257D-550 with CSIII lock
Time Interval – Generate and Measure	1 ns to 10 s	0.92 ns + *TI**0.04 parts in 10^{6}	33250A 53132A/12 *TI* = Time Interval

IV. Thermodynamics

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Temperature-Measure	20 °C to 30 °C	0.13 °C	5628/1502
Relative Humidity – Measure -20 °C to 20 °C 20 °C to 30 °C 30 °C to 50 °C	(10 to 90) % RH	3.5 % rdg 2.3 % rdg 3.5 % rdg	SP 2000

[1] This laboratory does not normally offer commercial calibration services.

[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] 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] Type N using 7mm to N adapter; uncertainty of adapter combines with that of device under test.

[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. Best measurement uncertainties are 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 Best Uncertainty does not include the effects of mismatch error.