

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

AGILENT TECHNOLOGIES  
 LOVELAND STANDARDS LAB  
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CALIBRATION

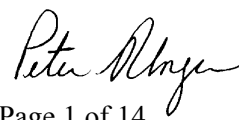
Valid To: October 31, 2011

Certificate Number: 979.02

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations<sup>1</sup>:

I. Electrical – DC/Low Frequency

Parameter/Range	Frequency	CMC <sup>2,3,4</sup> (±)	Comments
AC Current – Measure			
10 µA	10 Hz to 10 kHz	0.018 %	Fluke 5790A AC measurement standard with Agilent ET22703 shunt box
100 µA	10 Hz to 10 kHz	0.017 %	
(1 to 100) mA	10 Hz	0.015 %	
	20 Hz to 10 kHz	0.012 %	
300 mA	10 Hz to 10 kHz	0.017 %	
1 A	10 Hz to 10 kHz	0.017 %	
10 A	40 Hz to 1 kHz	0.021 %	HP 3458A with 0.001 Ω shunt
	(1 to 5) kHz	0.049 %	
	(5 to 10) kHz	0.060 %	



Parameter/Range	Frequency	CMC <sup>2,3,4</sup> (±)	Comments
AC Current – Generate, Fixed Points  10 µA 100 µA 1 mA 10 mA 100 mA 1 A	1 kHz	0.076 % 0.015 % 0.014 % 0.013 % 0.014 % 0.015 %	Datron 4700 calibrator
AC Voltage – Measure, Fixed Points  1 mV       3 mV          10 mV	(10 to 100) Hz 100 Hz to 1 kHz (1 to 20) kHz (20 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz  (10 to 20) Hz (20 to 100) Hz 100 Hz to 1 kHz (1 to 20) kHz (20 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz  (10 to 20) Hz (20 to 100) Hz 100 Hz to 1 kHz (1 to 20) kHz (20 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.087 % 0.08 % 0.13 % 0.15 % 0.30 % 0.42 % 0.72 %  0.019 % 0.015 % 0.016 % 0.019 % 0.043 % 0.065 % 0.14 % 0.32 %  0.010 % 73 µV/V 71 µV/V 0.013 % 0.036 % 0.056 % 0.092 % 0.20 %	Fluke 5790A AC measurement standard

Parameter/Range	Frequency	CMC <sup>2,3,4</sup> (±)	Comments	
AC Voltage – Measure, Fixed Points (cont)	30 mV	(10 to 20) Hz	0.015 %	Fluke 5790A AC measurement standard
		(20 to 100) Hz	82 µV/V	
		100 Hz to 1 kHz	81 µV/V	
		(1 to 20) kHz	72 µV/V	
		(20 to 100) kHz	0.025 %	
		(100 to 300) kHz	0.032 %	
		(300 to 500) kHz	0.055 %	
		500 kHz to 1 MHz	0.13 %	
	100 mV	(10 to 20) Hz	0.01 %	
		(20 to 100) Hz	61 µV/V	
		100 Hz to 1 kHz	61 µV/V	
		(1 to 20) kHz	53 µV/V	
		(20 to 100) kHz	0.024 %	
		(100 to 300) kHz	0.030 %	
		(300 to 500) kHz	0.050 %	
		500 kHz to 1 MHz	0.13 %	
	300 mV	(10 to 20) Hz	71 µV/V	
		(20 to 100) Hz	45 µV/V	
		100 Hz to 1 kHz	37 µV/V	
		(1 to 20) kHz	38 µV/V	
(20 to 100) kHz		73 µV/V		
(100 to 300) kHz		0.012 %		
(300 to 500) kHz		0.014 %		
500 kHz to 1 MHz		0.015 %		
1 V	(10 to 20) Hz	53 µV/V		
	(20 to 100) Hz	28 µV/V		
	100 Hz to 1 kHz	19 µV/V		
	(1 to 20) kHz	22 µV/V		
	(20 to 100) kHz	65 µV/V		
	(100 to 300) kHz	0.011 %		
	(300 to 500) kHz	0.012 %		
	500 kHz to 1 MHz	0.015 %		
3 V	(10 to 20) Hz	61 µV/V		
	(20 to 100) Hz	40 µV/V		
	100 Hz to 1 kHz	29 µV/V		
	(1 to 20) kHz	38 µV/V		
	(20 to 100) kHz	74 µV/V		
	(100 to 300) kHz	0.012 %		
	(300 to 500) kHz	0.015 %		
	500 kHz to 1 MHz	0.033 %		

Parameter/Range	Frequency	CMC <sup>2,3,4</sup> (±)	Comments
AC Voltage – Measure, Fixed Points (cont)			
10 V	(10 to 20) Hz (20 to 100) Hz 100 Hz to 1 kHz (1 to 20) kHz (20 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	54 µV/V 38 µV/V 20 µV/V 24 µV/V 67 µV/V 0.012 % 0.015 % 0.029 %	Fluke 5790A AC measurement standard
30 V	(10 to 20) Hz (20 to 100) Hz 100 Hz to 1 kHz (1 to 20) kHz (20 to 100) kHz	53 µV/V 40 µV/V 32 µV/V 39 µV/V 68 µV/V	
100 V	(10 to 20) Hz (20 to 100) Hz 100 Hz to 1 kHz (1 to 20) kHz (20 to 100) kHz	54 µV/V 35 µV/V 28 µV/V 30 µV/V 67 µV/V	
300 V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz (30 to 50) kHz (50 to 100) kHz	33 µV/V 38 µV/V 49 µV/V 58 µV/V 0.012 %	
500 V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz (30 to 50) kHz (50 to 100) kHz	34 µV/V 43 µV/V 51 µV/V 70 µV/V 0.013 %	
700 V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz (30 to 50) kHz (50 to 100) kHz	45 µV/V 53 µV/V 74 µV/V 91 µV/V 160 µV/V	
1000 V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	37 µV/V 46 µV/V 52 µV/V	

Parameter/Range	Frequency	CMC <sup>2,3,4</sup> (±)	Comments		
AC Voltage – Generate, Fixed Points	10 mV	1 kHz	60 µV/V	Datron 4700 calibrator plus divider	
		20 kHz	0.012 %		
		100 kHz	0.036 %		
		300 kHz	0.054 %		
		1 MHz	0.18 %		
	100 mV	4 MHz	0.37 %	HP 3325A function generator	
		1 kHz	50 µV/V	Datron 4700 calibrator plus divider	
			20 kHz		0.005 %
			100 kHz		0.024 %
			300 kHz		0.031 %
	1 MHz	0.12 %			
	1 V	4 MHz	0.35 %	HP 3325A function generator	
		8 MHz	0.54 %		
		10 MHz	0.64 %		
1 kHz		30 µV/V	Fluke 5790A AC measurement standard		
		20 kHz		30 µV/V	
		50 kHz		40 µV/V	
		100 kHz		60 µV/V	
		300 kHz		0.011 %	
		500 kHz		0.016 %	
		1 MHz		0.039 %	
4 MHz	0.35 %	HP 3325A function generator			
	8 MHz		0.54 %		
	10 MHz		0.65 %		
3 V	100 kHz	0.007 %	Fluke 5790A AC measurement standard		
	2 MHz	0.34 %	HP 3325A function generator		
		4 MHz		0.35 %	
		8 MHz		0.53 %	
		8 MHz		0.53 %	
		10 MHz		0.65 %	

Parameter/Range	Frequency	CMC <sup>2,3,4</sup> (±)	Comments
AC Voltage – Generate, Fixed Points (cont)			
10 V	10 Hz 20 Hz 40 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 1 MHz	60 μV/V 40 μV/V 40 μV/V 30 μV/V 30 μV/V 30 μV/V 40 μV/V 70 μV/V 0.012 % 0.018 % 0.045 %	Fluke 5790A AC measurement
100 V	1 kHz 20 kHz 50 kHz 100 kHz	30 μV/V 30 μV/V 40 μV/V 70 μV/V	
700 V	1 kHz 20 kHz	40 μV/V 40 μV/V	
1000 V	1 kHz 20 kHz	40 μV/V 40 μV/V	
AC Voltage, Wideband – Measure			
Absolute Voltage			
1 mV to 3 V	10 Hz to 500 kHz 500 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.10 % + 1.6 μV 0.13 % + 1.3 μV 0.16 % + 1.2 μV 0.27 % + 1.1 μV 0.27 % + 1.1 μV	Fluke 5790A AC measurement standard

Parameter/Range	Frequency	CMC <sup>2,3,4</sup> (±)	Comments
AC Voltage, Wideband – Measure (cont)			
Voltage Flatness			
(1 to 3) mV	10 Hz to 120 kHz 120 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.029 % 0.091 % 0.21 % 0.31 % 0.32 %	Fluke 5790A AC measurement standard
(10 to 300) mV	10 Hz to 120 kHz 120 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.025 % 0.082 % 0.19 % 0.29 % 0.32 %	
(1 to 3) V	10 Hz to 120 kHz 120 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.019 % 0.074 % 0.16 % 0.28 % 0.32 %	
Capacitance – Measure, Fixed Points			
2/3 Terminal Pair (TP)			
1 pF 10 pF 100 pF 1000 pF 0.01 μF 0.1 μF 1 μF	1 kHz	0.029 fF 0.011 fF 0.57 fF 18 fF 0.33 pF (Df = 0.000014) 3.9 pF (Df = 0.000029) 46 pF (Df = 0.000097)	AH 2500A bridge with 10 and 100 pF silica capacitance standards

Parameter/Range	Frequency	CMC <sup>2,4</sup> (±)	Comments
Capacitance – Measure, Fixed Points (cont)			
4 Terminal Pair – Dissipation Factors			
1 pF			
0.00002	1 kHz	44 µF/F	AH 2500A bridge
0.00003	1 MHz	90 µF/F	Agilent 8753C network analyzer plus Agilent 85046A S-parameter test set
0.00006	2 MHz	0.023 %	
0.00009	3 MHz	0.041 %	
4 Terminal Pair – Dissipation Factors			
1 pF			
0.00014	4 MHz	0.063 %	AH 2500A bridge
0.0002	5 MHz	0.088 %	Agilent 8753C network analyzer plus Agilent 85046A S-parameter test set
0.00057	10 MHz	0.25 %	
0.00083	13 MHz	0.37 % (all values @ k=2)	
10 pF			
0.00002	1 kHz	39 µF/F	AH 2500A bridge
0.00002	1 MHz	39 µF/F	Agilent 8753C network analyzer plus Agilent 85046A S-parameter test set
0.00002	2 MHz	40 µF/F	
0.00002	3 MHz	43 µF/F	
0.00002	4 MHz	47 µF/F	
0.00003	5 MHz	54 µF/F	
0.00007	10 MHz	0.012 %	
0.00009	13 MHz	0.016 % (all values @ k=2)	
100 pF			
0.00002	1 kHz	38 µF/F	AH 2500A bridge
0.00002	1 MHz	40 µF/F	Agilent 8753C network analyzer plus Agilent 85046A S-parameter test set
0.00002	2 MHz	48 µF/F	
0.00003	3 MHz	66 µF/F	
0.00005	4 MHz	91 µF/F	
0.00006	5 MHz	0.013 %	
0.00016	10 MHz	0.033 %	
0.00024	13 MHz	0.049 % (all values @ k=2)	

*Peter Mlynar*

Parameter/Range	Frequency	CMC <sup>2,4</sup> (±)	Comments
Capacitance – Measure, Fixed Points (cont)			
1000 pF			
0.00002	1 kHz	41 µF/F	AH 2500A bridge
0.00003	1 MHz	64 µF/F	Agilent 8753C network analyzer plus Agilent 85046A S-parameter test set
0.00006	2 MHz	0.015 %	
0.0001	3 MHz	0.028 %	
0.00015	4 MHz	0.044 %	
0.00021	5 MHz	0.062 %	
0.00058	10 MHz	0.19 %	
0.00085	13 MHz	0.28 %	
		(all values @ k=2)	
0.01 µF			
0.0001	120 Hz, 1 kHz	40 µF/F	Agilent 4284 LCR meter, 16074A kit, 16380C kit
0.0002	10 kHz	40 µF/F	
0.0003	100 kHz	40 µF/F	
		(all values @ k=2)	
0.1 µF			
0.0001	120 Hz, 1 kHz	40 µF/F	Agilent 4284A LCR meter, 16074A kit, 16380C kit
0.0002	10 kHz	40 µF/F	
0.0005	100 kHz	40 µF/F	
		(all values @ k=2)	
4 Terminal Pair – Dissipation Factors			
1 µF			
0.00015	120 Hz	50 µF/F	Agilent 4284A LCR meter, 16074A kit, 16380C kit
0.0001	1 kHz	40 µF/F	
0.0004	10 kHz	40 µF/F	
0.002	100 kHz	70 µF/F	
		(all values @ k=2)	
10 µF			
0.00004	120 Hz	50 µF/F	Agilent 4284A LCR meter, 16074A kit, 16380C kit
0.00003	1 kHz	50 µF/F	
0.00004	100 kHz	0.01 %	
		(all values @ k=2)	

Parameter/Range	Frequency	CMC <sup>2,4</sup> (±)	Comments
HF Resistance – Measure, Fixed Points			
4 Terminal Pair			
10 Ω	1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	0.03 % 0.05 % 0.06 % 0.07 % 0.1 % 0.4 % 0.6 %	Agilent 4285A LCR meter, HP 3458A DMM, 16074A resistance kit plus 16380C capacitance kit
100 Ω	1 MHz 2 MHz (3, 4, 5) MHz 10 MHz 13 MHz	0.03 % 0.04 % 0.05 % 0.2 % 0.3 %	
1 kΩ	100 kHz (1, 2, 3) MHz 4 MHz 5 MHz 10 MHz 13 MHz	0.03 % 0.03 % 0.04 % 0.05 % 0.2 % 0.3 % (all values @ k=2)	
10 kΩ	100 kHz 1 MHz	0.02 % 0.03 %	
100 kΩ	100 kHz 1 MHz	0.03 % 0.03 % (all values @ k=2)	

Parameter/Range	Frequency	CMC <sup>2, 4</sup> (±)	Comments
HF Reactance – Measure, Fixed Points  10 Ω       100 Ω	1 MHz (2, 3) MHz 4 MHz 5 MHz 10 MHz 13 MHz  (1, 2, 3, 4, 5) MHz 10 MHz 13 MHz	4 mΩ 5 mΩ 6 mΩ 7 mΩ 20 mΩ 40 mΩ  40 mΩ 80 mΩ 90 mΩ (all values @ k=2)	Agilent 4285A LCR meter, HP 3458A DMM, 16074A resistance kit plus 16380C capacitance kit
HF Susceptance – Measure, Fixed Points  1 kΩ   10 kΩ   100 kΩ	100 kHz (1, 2, 3, 4, 5) MHz (10, 13) MHz  100 kHz 1 MHz  100 kHz 1 MHz	0.4 μS 0.4 μS 0.7 μS  0.04 μS 0.04 μS  0.004 μS 0.004 μS (all values @ k=2)	Agilent 4285A LCR meter, HP 3458A DMM, 16074A resistance kit plus 16380C capacitance kit
Inductance (series) – Measure Using LCR Meter  Resistance Test Set Units:  0.1 Ω 1 Ω 10 Ω 100 Ω	1 MHz	1.0 nH 0.30 nH 1.0 nH 7.0 nH (all values @ k=2)	Agilent 4284A & Agilent 4284A LCR Meters, HP 3458A, 16074A resistance kit, 1680A capacitance kit

Parameter/Range	Frequency	CMC <sup>2,4</sup> (±)	Comments
Capacitance (parallel) – Measure, Fixed Points Using LCR Meter  Resistance Test Set Units:  100Ω 1 kΩ 10 kΩ 100 kΩ	1 MHz	0.7 pF 0.07 pF 0.02 pF 0.004 pF (all values @ k=2)	Agilent 4285A LCR meter, HP 3458A, 16074A resistance kit, 1680A capacitance kit
Thermal Voltage Converters – Measure  (0.5 to 3) V	10 Hz 100 Hz (10, 30) kHz 100 kHz 300 kHz 1 MHz  (3, 8, 10) MHz (20, 30) MHz 50 MHz 70 MHz 80 MHz 100 MHz	0.015 % 0.0070 % 0.0070 % 0.0080 % 0.013 % 0.013 %  0.12 % 0.25 % 0.62 % 0.93 % 1.1 % 1.3 %	Holt 11 TVC       Ballantine 1395A TVCs

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
DC Voltage – Measure, Fixed Points	0.1 V 1 V 10 V 100 V 1000 V	2.0 μV/V 1.0 μV/V 0.50 μV/V 1.1 μV/V 1.1 μV/V	Fluke 732 plus fixed oil resistors, 3458A DMM

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
DC Voltage – Generate, Fixed Points	150 μV to 10 V	0.1 μV/V + 100 nV	Array Josephson Junction
	0.1 V 1 V 10 V  100 V 1 kV	1.0 μV/V 0.35 μV/V 0.36 μV/V  0.8 μV/V 2.0 μV/V	Fixed oil resistors, Fluke 732 plus 3458A DMM  Fixed oil resistors, Datron 4800A calibrator, 3458A DMM
DC Resistance – Measure, Fixed Points	0.001 Ω 0.01 Ω 0.1 Ω  1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ  100 kΩ 1 MΩ 10 MΩ  100 MΩ 1 GΩ 10 GΩ 100 GΩ	0.58 μΩ/Ω 0.58 μΩ/Ω 0.58 μΩ/Ω  0.51 μΩ/Ω 0.74 μΩ/Ω 0.73 μΩ/Ω 0.73 μΩ/Ω 0.76 μΩ/Ω  1.8 μΩ/Ω 5.5 μΩ/Ω 19 μΩ/Ω  90 μΩ/Ω 0.029 % 0.035 % 0.031 %	Resistance shunts in oil  L&N oil bath resistors with MI 6010B bridge  Strings of oil bath resistors with 3458A and current source  Agilent 3458A intercomparison with 100 MΩ, 1 GΩ SL266513, 10 GΩ SL266514, 100 GΩ
	DC Resistance – Generate, Fixed Points	1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ 1 MΩ 10 MΩ 100 MΩ 1 GΩ	1.0 μΩ/Ω 1.0 μΩ/Ω 1.0 μΩ/Ω 1.0 μΩ/Ω 1.0 μΩ/Ω 1.0 μΩ/Ω 2.0 μΩ/Ω 5.0 μΩ/Ω 0.010 % 0.20 %

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
DC Current – Generate, Fixed Points	100 nA 1 µA 10 µA (0.1, 1, 10, 100) mA 1 A	17 µA/A 10 µA/A 10 µA/A 1.6 µA/A 2.6 µA/A	Fixed resistors in oil plus 3458A DMM
DC Current – Measure, Fixed Points	100 µA to 300 mA 1 A 10 A	1.7 µA/A 2.6 µA/A 40 µA/A	Fixed resistors in oil plus 3458A DMM
Ratio Transformer – Magnitude Only	(1 to 100) V input, 1 kHz	0.51 parts in 10 <sup>6</sup> of input	ESI-DT72A ratio transformer

<sup>1</sup> This laboratory offers commercial calibration service.

<sup>2</sup> 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.

<sup>3</sup> The measurands stated are generated with the Fluke 5790A instrument. This capability is suitable for the calibration of the devices intended to measure the stated measurand in the ranges indicated. CMCs are expressed as either a specific value that covers the full range or as a fraction of the reading plus a fixed floor specification.

<sup>4</sup> In the statement of CMC, percentages are to be read as percent of reading, unless otherwise indicated.



World Class Accreditation

The American Association for Laboratory Accreditation

## Accredited Laboratory

A2LA has accredited

# AGILENT TECHNOLOGIES LOVELAND STANDARDS LAB

*Loveland, CO*

for technical competence in the field of

## Calibration

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General Requirements for the Competence of Testing and Calibration Laboratories*. This laboratory also meets the requirements of ANSI/NCSL Z540-1-1994 and any additional program requirements in the field of calibration. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009*).



Presented this 27th day of October 2009.

A handwritten signature in black ink, appearing to read "Peter Meyer".

President & CEO  
For the Accreditation Council  
Certificate Number 0979.02  
Valid to October 31, 2011

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