



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

AGILENT TECHNOLOGIES  
 LOVELAND STANDARDS LAB  
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CALIBRATION

Valid To: October 31, 2013

Certificate Number: 0979.02

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 1kHz	0.016 %	Fluke 5790A AC measurement standard with Agilent ET22703 shunt box
10 µA	1kHz to 10 kHz	0.015 %	
100 µA	10 Hz to 20Hz	0.014 %	
100 µA	20Hz to 10 kHz	0.013 %	
(1 to 100) mA	10 Hz to 20 Hz	0.012 %	
	20 Hz to 10 kHz	0.011 %	
300 mA	10 Hz to 10 kHz	0.017 %	
1 A	10 Hz to 20 Hz	0.014 %	
	20 Hz to 10 kHz	0.013 %	
10 A	40 Hz to 1kHz	0.022 %	HP 3458A with 0.001 Ω shunt
	1 kHz to 5 kHz	0.048 %	
	(5 to 10) kHz	0.064 %	

Parameter/Range	Frequency	CMC <sup>2,3,4</sup> (±)	Comments
AC Current – Generate, Fixed Points			
10 µA	1 kHz	0.071 %	Fluke 5720A calibrator
100 µA		0.015 %	
1 mA		0.012 %	
10 mA		0.012 %	
100 mA		0.012 %	
1 A		0.015 %	
10 A	40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.015 % 0.019 % 0.026 %	
AC Voltage – Measure, Fixed Points			
1 mV	(10 to 20) Hz 20 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	0.069 % 0.065 % 0.069 % 0.093% 0.27 % 0.42 % 0.68 %	Fluke 5790A AC measurement standard
3 mV	(10 to 20) Hz 20 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	0.015 % 0.012 % 0.012 % 0.027 % 0.060 % 0.14 % 0.29 %	
10 mV	(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	85 µV/V 66 µV/V 63 µV/V 69 µV/V 0.021 % 0.044% 0.083 % 0.15%	

Parameter/Range	Frequency	CMC <sup>2,3,4</sup> (±)	Comments
AC Voltage – Measure, Fixed Points (cont)			
30 mV	(10 to 20) Hz 20 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	85 µV/V 65 µV/V 77 µV/V 0.013 % 0.022 % 0.046 % 0.10 %	Fluke 5790A AC measurement standard
100 mV	(10 to 20) Hz 20 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	68 µV/V 50 µV/V 47 µV/V 0.012 % 0.019 % 0.039 % 0.08 %	
300 mV	(10 to 20) Hz 20 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	50 µV/V 40 µV/V 37 µV/V 45 µV/V 79 µV/V 0.014 % 0.029 %	
1 V	(10 to 20) Hz (20 to 40) Hz 40 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	44 µV/V 35 µV/V 27 µV/V 22 µV/V 26 µV/V 46 µV/V 77 µV/V 0.024%	
3 V	(1 to 100) kHz	24 µV/V	
6V	1 kHz	28 µV/V	

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	42 µV/V 34 µV/V 19 µV/V 21 µV/V 26 µV/V 61 µV/V 0.010 % 0.028 %	Fluke 5790A AC measurement standard
19V	1 kHz	24 µV/V	
100 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 100) kHz (100 to 200) kHz	51 µV/V 33 µV/V 27 µV/V 29 µV/V 42 µV/V 72 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 37 µV/V 37 µV/V 58 µV/V 98 µV/V	
500 V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz (30 to 50) kHz (50 to 100) kHz	30 µV/V 33 µV/V 38 µV/V 59 µV/V 0.012 %	
700 V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz (30 to 50) kHz (50 to 100) kHz	36 µV/V 50 µV/V 60 µV/V 82 µV/V 0.014 %	
1000 V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	41 µV/V 38 µV/V 57 µV/V	

Parameter/Range	Frequency	CMC <sup>2,3,4</sup> (±)	Comments		
AC Voltage – Generate, Fixed Points	10 mV	1 kHz	53 µV/V	Fluke 5720A calibrator plus divider	
		20 kHz	62 µV/V		
		100 kHz	0.020 %		
		300 kHz	0.040 %		
		1 MHz	0.15 %		
	100 mV	4 MHz	0.37 %	HP 3325A function generator	
		1 kHz	39 µV/V	Fluke 5720A calibrator plus divider	
			20 kHz		42 µV/V
			100 kHz		0.011 %
			300 kHz		0.018 %
			1 MHz		0.076 %
		1 V	4 MHz	0.35 %	HP 3325A function generator
			8 MHz	0.54 %	
			10 MHz	0.64 %	
1 kHz			22 µV/V	Fluke 5790A AC measurement standard	
	20 kHz		25 µV/V		
	50 kHz	30 µV/V			
	100 kHz	32 µV/V			
	300 kHz	57 µV/V			
	500 kHz	0.011 %			
	1 MHz	0.038 %			
3 V	4 MHz	0.35 %	HP 3325A function generator		
		8 MHz		0.54 %	
		10 MHz		0.65 %	
	100 kHz	34 µV/V	Fluke 5790A AC measurement standard		
		2 MHz		0.34 %	
		4 MHz		0.35 %	
		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 4 kHz 8 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 1 MHz	52 µV/V 39 µV/V 36 µV/V 23 µV/V 23 µV/V 23 µV/V 23 µV/V 23 µV/V 34 µV/V 35 µV/V 73 µV/V 0.013 % 0.044 %	Fluke 5790A AC measurement
100 V	1 kHz 20 kHz 50 kHz 100 kHz	27 µV/V 28 µV/V 37 µV/V 49 µV/V	
700 V	1 kHz 20 kHz	32 µV/V 39 µV/V	
1000 V	1 kHz 20 kHz	61 µV/V 93 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>2,4</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 Abney*

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	0.03 %	Agilent 4285A LCR meter, HP 3458A DMM, 16074A resistance kit plus 16380C capacitance kit	
	2 MHz	0.05 %		
	3 MHz	0.06 %		
	4 MHz	0.07 %		
	5 MHz	0.1 %		
	10 MHz	0.4 %		
	13 MHz	0.6 %		
100 Ω	1 MHz	0.03 %		
	2 MHz	0.04 %		
	(3, 4, 5) MHz	0.05 %		
	10 MHz	0.2 %		
	13 MHz	0.3 %		
1 kΩ	100 kHz	0.03 %		
	(1, 2, 3) MHz	0.03 %		
	4 MHz	0.04 %		
	5 MHz	0.05 %		
	10 MHz	0.2 %		
	13 MHz	0.3 %		
		(all values @ k=2)		
10 kΩ	100 kHz	0.02 %	Agilent 4285A LCR meter, HP 3458A DMM, 16074A resistance kit plus 16380C capacitance kit	
	1 MHz	0.03 %		
100 kΩ	100 kHz	0.03 %		
	1 MHz	0.03 %		
		(all values @ k=2)		

Parameter/Range	Frequency	CMC <sup>2</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 4285A 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</sup> (±)	Comments
DC Voltage – Measure, Fixed Points	0.1 V 1 V 10 V 100 V 1000 V	6.0 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 0.21 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 & Generate, Fixed Points	0.001 Ω 0.01 Ω 0.1 Ω	0.58 μΩ/Ω 0.58 μΩ/Ω 0.58 μΩ/Ω	Resistance shunts in oil
	1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ  100 kΩ 1 MΩ 10 MΩ  100 MΩ 1 GΩ 10 GΩ 100 GΩ	0.51 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 %	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 Current – Generate, Fixed Points	100 nA 1 μA 10 μA 0.1 mA 1 mA 10 mA 100 mA 1 A	35 μA/A 14 μA/A 14 μA/A 3.4 μA/A 2.3 μA/A 3.2 μA/A 6.7 μA/A 42 μA/A	Fixed resistors in oil plus 3458A DMM

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
DC Current – Measure, Fixed Points	100 µA to 300 mA 1 A 10 A	1.7 µA/A 5.0 µA/A 22 µA/A	Fixed resistors in oil plus 3458A DMM
Ratio Transformer – Magnitude Only	(1 to 100) V input, 1 kHz	0.52 parts in 10 <sup>6</sup> of input	ESI-DT72A ratio transformer

## II. Time and Frequency

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Frequency	10 MHz	$2.7 \times 10^{-9}$ Hz	58503A GPS receiver – signal tracked and compared with NIST

<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. Unless noted, Calibration and Measurement Capabilities represent expanded uncertainties expressed at approximately the 99.7 % level of confidence, usually using a coverage factor of  $k = 3$ . Where a coverage factor of  $k = 2$  is noted, this represents expanded uncertainties expressed at approximately the 95 % confidence level. 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.



The American Association for Laboratory Accreditation

World Class 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 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 1<sup>st</sup> day of September 2011.

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

President & CEO  
For the Accreditation Council  
Certificate Number 979.02  
Valid to October 31, 2013

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