

Supplementary Information



Standards Laboratory Calibration

Order Number 1-xxxxxxxxxx-1

Model Number 3458A
Manufacturer Keysight Technologies Inc
Description Digital multimeter, 8.5 digit
Serial Number /HERE SN/
Options Installed 002

Customer
Keysight Technologies Deutschland GmbH
Herrenberger Strasse 130
71034 BOEBLINGEN
Germany

Date of Calibration 5Mar 2021
Procedure
Temperature (23 ± 1) °C
Humidity (40 ± 20) %RH

Location of Calibration
Keysight Technologies UK Limited
610 Wharfedale Road
Winnersh Triangle
Wokingham Berkshire RG41 5TP
UNITED KINGDOM

Remarks or Special Requirements

THIS COVER SHEET IS SUPPLEMENTARY TO THE ACCREDITED CALIBRATION CERTIFICATE.

Calibration Equipment Used

Model Number	Model Description	Equipment ID	Cal Due Date	Order Number
100M	100 MOhm Resistance box	UK7709	18 Nov 2021	1-xxxxxxxxxx-1
1G	Resistance Std.	UK7708	12 Sep 2021	1-xxxxxxxxxx-1
3325A	Synthesizer/Function Generator	UK7740	1 Feb 2022	1-xxxxxxxxxx-1
3458A	Digital multimeter, 8.5 digit	UK11880	12 Feb 2022	1-xxxxxxxxxx-1
3458A	Digital multimeter, 8.5 digit	UK8606	19 Mar 2021	1-xxxxxxxxxx-1
4000A	Calibrator, Transconductance AMP	UK5802	22 Feb 2022	1-xxxxxxxxxx-1
4035-B	Standard Resistor	DE915	26 Mar 2021	1-xxxxxxxxxx-1
4200	AC Standard Calibrator	UK5906	25 Jan 2022	1-xxxxxxxxxx-1
5071A	Primary frequency standard	UK13623	18 Feb 2022	1-xxxxxxxxxx-1
5685A	AC/DC Standard Resistor	UK7301	25 Sep 2021	1-xxxxxxxxxx-1
5685A	AC/DC Standard Resistor	UK7677	26 Apr 2021	1-xxxxxxxxxx-1
5685A	AC/DC Standard Resistor	UK5564	26 Apr 2021	1-xxxxxxxxxx-1
5720A	Calibrator	UK15273	10 Mar 2021	1-xxxxxxxxxx-1
5790A	AC Voltmeter	UK15582	5 Jan 2022	1-xxxxxxxxxx-1
732A	DC Reference Standard	UK8509	20 Feb 2022	1-xxxxxxxxxx-1
752A	Reference Divider	UK11024	13 Nov 2021	1-xxxxxxxxxx-1
80010	Standard Resistor	UK4275	26 Apr 2021	1-xxxxxxxxxx-1
9330	Standard Resistor	UK5465	26 Sep 2021	1-xxxxxxxxxx-1
9330	Standard Resistor	UK5379	1 Oct 2021	1-xxxxxxxxxx-1
A40	Current Shunt	DE1748	1 Oct 2021	1-xxxxxxxxxx-1
RS3	Standard Resistor	UK5468	24 Apr 2021	1-xxxxxxxxxx-1
SR104	Standard Resistor	ITSVC311	16 Sep 2021	1-xxxxxxxxxx-1

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Mike Horsefield - Approved Signatory

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APPROVED SIGNATORY


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Instrument Description: Digital Multimeter

Instrument Manufacturer: Keysight Technologies

Model Number: 3458A

Serial Number: -HERE SN-

Our Reference Number: 1-XXXXXXXXXXXX-1

Customer: Keysight Technologies Deutschland GmbH, 71034 BOEBLINGEN, Germany

Date Of Calibration: 5 March 2021

Ambient Temperature: (23 ± 1) °C Relative Humidity: (40 ± 20) %

REMARKS:

The on-receipt calibration status of the item is shown in the following report. The documented results relate to the equipment calibrated only.

The measured values were observed in specification at the points tested. Additionally, the expanded measurement uncertainty intervals about the measured values were in specification.

TEST DESCRIPTION:

The 1-year specification has been used to define the absolute test limits in this certificate. They include the original manufacturer's calibration uncertainty for NIST traceability as published in the product's Calibration Manual 03458-90017:Dec2000.

A minimum warm-up period of 4 hours was allowed before testing. In accordance with the manufacturer's recommended practice, the appropriate "ACAL" routines were invoked before testing each function.

The Firmware version reported by REV? was
The value for CALNUM? reported by the 3458A PRIOR to testing was
and at COMPLETION of testing was

7.2
138
138

The uncertainty of measurement has been taken into account when determining compliance with specification, as per ILAC-G8:09/2019. The "Accredited Calibration" service employs a guard band in the amount of the 95% expanded measurement uncertainty (MU). The resulting acceptance limit applied for Pass or Fail decisions, and for performing adjustments, is the difference of the specification and the guard band. For more information on the level of risk such as false accept and false reject and statistical assumptions of these statements of conformity please visit: www.keysight.com/find/decisionrules.

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a coverage probability of approximately 95%.

Any quoted uncertainty refers only to the measured value and does not carry any implication regarding the long term stability of the instrument.

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to the SI system of units and/or to units of measurement realised at the National Physical Laboratory or other recognised national metrology institutes. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

CERTIFICATE OF CALIBRATION



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Applicable Specification :

- Standard
 Option 002

DC Voltage Accuracy

Last calibration internal temperature (Cal? 59) = **35.33** °C
 Present internal temperature (Temp?) = **34.6** °C

3458A set-up: NPLC 500, NDIG 8

Zero Offsets

A low thermal short was connected to the input terminals.

Applied	Range	Specification (applied ± limit)	Measured Value	Uncertainty	Status (if applicable)
0 mV	100 mV	± 0.9 µV	-0.00008 mV	0.11 µV	
0 V	1 V	± 1.0 µV	-0.00000009 V	0.11 µV	
0 V	10 V	± 2.0 µV	-0.0000001 V	0.21 µV	
0 V	100 V	± 30 µV	0.000012 V	1.0 µV	
0 V	1000 V	± 100 µV	0.00000 V	12 µV	

Gain

The following measurements used the multimeter's "Math Null" function to exclude thermal emf's and other internal offsets from the measured value.

Applied	Range	Specification (applied ± limit)	Measured Value	Uncertainty	Status (if applicable)
100 mV	100 mV	± 1.00 µV	99.99975 mV	0.34 µV	
-100 mV	100 mV	± 1.00 µV	-99.99983 mV	0.34 µV	
1 V	1 V	± 6.3 µV	0.99999940 V	1.7 µV	
-1 V	1 V	± 6.3 µV	-0.99999760 V	1.7 µV	
10 V	10 V	± 60.5 µV	9.9999810 V	15 µV	
-10 V	10 V	± 60.5 µV	-9.9999797 V	15 µV	
100 V	100 V	± 830 µV	99.999886 V	120 µV	
-100 V	100 V	± 830 µV	-99.999846 V	120 µV	
1000 V	1000 V	± 20.1 mV	999.99534 V	1.3 mV	
-1000 V	1000 V	± 20.1 mV	-999.99513 V	1.3 mV	

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AC Voltage Accuracy (Synchronous mode)

A voltage of substantially sinusoidal form was applied to the 3458A input.

3458A set-up: SETACV SYNC; RES .001

LFILTER ON; for frequencies <= 50 kHz, otherwise LFILTER OFF

ACBAND 10,1E6 for frequencies <= 1 MHz, except 10 mV @ 1 MHz which uses ACBAND 10,1E7

ACBAND 10,1E7 for frequencies > 1 MHz

Applied		Range	Specification (applied \pm limit)	Measured Value	Uncertainty	Status (if applicable)
10 mV	1 kHz	10 mV	$\pm 3.12 \mu\text{V}$	9.99990 mV	0.72 μV	
10 mV	20 kHz	10 mV	$\pm 4.12 \mu\text{V}$	9.99860 mV	1.1 μV	
10 mV	100 kHz	10 mV	$\pm 51.12 \mu\text{V}$	9.97591 mV	4.2 μV	
10 mV	300 kHz	10 mV	$\pm 402.02 \mu\text{V}$	9.79952 mV	6.6 μV	
100 mV	1 kHz	100 mV	$\pm 9.2 \mu\text{V}$	100.0045 mV	4.6 μV	
100 mV	20 kHz	100 mV	$\pm 16.2 \mu\text{V}$	99.9993 mV	4.7 μV	
100 mV	100 kHz	100 mV	$\pm 82.2 \mu\text{V}$	99.9882 mV	5.4 μV	
100 mV	300 kHz	100 mV	$\pm 310.2 \mu\text{V}$	99.9767 mV	19 μV	
1 V	1 kHz	1 V	$\pm 92 \mu\text{V}$	1.000002 V	30 μV	
1 V	20 kHz	1 V	$\pm 162 \mu\text{V}$	0.999963 V	36 μV	
1 V	50 kHz	1 V	$\pm 322 \mu\text{V}$	0.999968 V	33 μV	
1 V	100 kHz	1 V	$\pm 822 \mu\text{V}$	0.999933 V	34 μV	
1 V	300 kHz	1 V	$\pm 3.102 \text{ mV}$	1.000513 V	0.15 mV	
1 V	500 kHz	1 V	$\pm 10.102 \text{ mV}$	1.001560 V	0.11 mV	
3 V	100 kHz	10 V	$\pm 2.602 \text{ mV}$	2.99827 V	0.12 mV	
10 V	10 Hz	10 V	$\pm 1.12 \text{ mV}$	10.00003 V	0.49 mV	
10 V	20 Hz	10 V	$\pm 1.12 \text{ mV}$	10.00005 V	0.44 mV	
10 V	40 Hz	10 V	$\pm 0.92 \text{ mV}$	10.00004 V	0.32 mV	
10 V	1 kHz	10 V	$\pm 0.92 \text{ mV}$	10.00018 V	0.32 mV	
10 V	10 kHz	10 V	$\pm 1.62 \text{ mV}$	9.99978 V	0.36 mV	
10 V	20 kHz	10 V	$\pm 1.62 \text{ mV}$	9.99967 V	0.36 mV	
10 V	50 kHz	10 V	$\pm 3.22 \text{ mV}$	9.99860 V	0.33 mV	
10 V	100 kHz	10 V	$\pm 8.22 \text{ mV}$	9.99467 V	0.33 mV	
10 V	300 kHz	10 V	$\pm 31.02 \text{ mV}$	9.97940 V	1.7 mV	
10 V	500 kHz	10 V	$\pm 101.02 \text{ mV}$	9.97829 V	1.3 mV	
10 V	1 MHz	10 V	$\pm 101.02 \text{ mV}$	10.04881 V	3.9 mV	
100 V	1 kHz	100 V	$\pm 0.0222 \text{ V}$	99.9988 V	0.0036 V	
100 V	20 kHz	100 V	$\pm 0.0222 \text{ V}$	99.9977 V	0.0043 V	
100 V	50 kHz	100 V	$\pm 0.0372 \text{ V}$	99.9931 V	0.0037 V	
100 V	100 kHz	100 V	$\pm 0.1222 \text{ V}$	99.9581 V	0.0038 V	
700 V	1 kHz	1000 V	$\pm 0.301 \text{ V}$	699.789 V	0.031 V	

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a coverage probability of approximately 95%.

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AC Voltage High Frequency

3458A set-up: SETACV SYNC; RES .001; ACBAND 10, 1E7

Input Voltage	Input Freq.	Expected Value	Measured Value	Difference	Tolerance	Uncertainty	Status (if applicable)
10 mV Range							
0.01 V	1 MHz	0.009951 V	0.009921 V	-0.000031 V	± 0.000125 V	0.024 mV	
0.01 V	4 MHz	0.00983 V	0.00940 V	-0.00043 V	± 0.00071 V	0.14 mV	
100 mV Range							
0.1 V	1 MHz	0.09981 V	0.09924 V	-0.00058 V	± 0.00101 V	0.18 mV	
0.1 V	4 MHz	0.09965 V	0.09655 V	-0.00310 V	± 0.00407 V	0.68 mV	
0.1 V	8 MHz	0.09916 V	0.09914 V	-0.00002 V	± 0.00408 V	0.68 mV	
0.1 V	10 MHz	0.0993 V	0.1045 V	0.0052 V	± 0.0151 V	2.3 mV	
1 V Range							
1 V	1 MHz	0.9979 V	0.9975 V	-0.0004 V	± 0.0101 V	1.7 mV	
1 V	4 MHz	0.9972 V	0.9723 V	-0.0249 V	± 0.0407 V	6.8 mV	
1 V	8 MHz	0.9919 V	0.9889 V	-0.0030 V	± 0.0408 V	6.8 mV	
1 V	10 MHz	0.992 V	1.035 V	0.043 V	± 0.151 V	25 mV	
10 V Range							
3 V	2 MHz	2.993 V	2.989 V	-0.004 V	± 0.127 V	21 mV	
3 V	4 MHz	2.986 V	2.951 V	-0.035 V	± 0.127 V	21 mV	
3 V	8 MHz	2.985 V	2.992 V	0.006 V	± 0.128 V	21 mV	
3 V	10 MHz	3.003 V	3.116 V	0.112 V	± 0.460 V	75 mV	

Frequency Accuracy

Applied Frequency	Specification (applied ± limit)	Measured Value	Uncertainty	Status (if applicable)
1 Hz 10 MHz	± 0.0005 Hz ± 0.001 MHz	0.999997 Hz 9.99997 MHz	0.000020 Hz 10 Hz	

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AC Voltage Accuracy (Analog mode)

A voltage of substantially sinusoidal form was applied to the 3458A input.
3458A set-up: SETACV ANA; NPLC 500; ACBAND 10,1E6

Applied		Range	Specification (applied \pm limit)	Measured Value	Uncertainty	Status (if applicable)
1 V	50 kHz	10 V	± 5.502 mV	0.99873 V	0.62 mV	
1 V	1 MHz	10 V	± 250 mV	0.89026 V	28 mV	
10 V	10 Hz	10 V	± 42.02 mV	9.98291 V	4.9 mV	
10 V	200 Hz	10 V	± 3.02 mV	10.00077 V	0.51 mV	
10 V	500 Hz	10 V	± 3.02 mV	10.00078 V	0.49 mV	
10 V	50 kHz	10 V	± 19.02 mV	9.99756 V	2.2 mV	
10 V	1 MHz	10 V	± 700.02 mV	10.02759 V	79 mV	

AC Current Accuracy

The applied current was of substantially sinusoidal form.
3458A set-up: ACBAND 10,1E4; LFILTER ON; NPLC 100
Note: The 100 mA and 1 A currents were applied for 5 minutes before measurement.

Applied		Range	Specification (applied \pm limit)	Measured Value	Uncertainty	Status (if applicable)
10 μ A	1 kHz	100 μ A	± 36.05 nA	10.0161 μ A	8.7 nA	
100 μ A	1 kHz	100 μ A	± 90.5 nA	100.0030 μ A	20 nA	
1 mA	1 kHz	1 mA	± 505 nA	1.000246 mA	160 nA	
10 mA	1 kHz	10 mA	± 5.05 μ A	10.00229 mA	1.1 μ A	
100 mA	1 kHz	100 mA	± 50.5 μ A	100.0220 mA	11 μ A	
1 A	1 kHz	1 A	± 1.205 mA	0.999899 A	0.15 mA	

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Resistance Accuracy

3458A set-up:

Below 100 megohm:

10 megohm and higher:

4-wire ohms; OCOMP ON; Delay 1; NPLC 100; NDIG 7

2-wire ohms; NPLC 500; NDIG 6

Last calibration internal temperature (Cal? 60) = 33.58 °C
Present temperature (Temp?) = 34.6 °C

Applied	Range	Spec.	Measured Value	Error	Uncertainty	Status (if applicable)
2-Wire Mode						
Front Input Shorted	10 Ω	± 0.25 ohms	0.08695 ohms	87.0 m ohm	0.50 m ohm	
Rear Input Shorted	10 Ω	± 0.25 ohms	0.05740 ohms	57.4 m ohm	0.50 m ohm	
4-Wire Mode						
Front Input Shorted	10 Ω	± 50 μ ohms	0.00000 ohms	0 μ ohm	10 μ ohm	
Rear Input Shorted	10 Ω	± 50 μ ohms	0.00000 ohms	0 μ ohm	10 μ ohm	
10.000000 Ω	10 Ω	± 23.0 ppm	10.000004 Ω	0.4 ppm	2.2 ppm	
100.00000 Ω	100 Ω	± 20.0 ppm	100.00009 Ω	0.9 ppm	2.1 ppm	
1.0000000 k Ω	1 kΩ	± 13.5 ppm	0.9999996 kΩ	-0.4 ppm	1.7 ppm	
10.000000 k Ω	10 kΩ	± 13.5 ppm	10.000015 kΩ	1.5 ppm	0.50 ppm	
100.00000 k Ω	100 kΩ	± 13.5 ppm	99.99997 kΩ	-0.3 ppm	3.9 ppm	
1.0000000 M Ω	1 MΩ	± 20.0 ppm	0.9999980 MΩ	-2.0 ppm	6.4 ppm	
10.000000 M Ω	10 MΩ	± 63.0 ppm	9.999868 MΩ	-13.2 ppm	13 ppm	
2-Wire Mode						
10.000000 M Ω	10 MΩ	± 63.0 ppm	9.999970 MΩ	-3.0 ppm	13 ppm	
100.0000 M Ω	100 MΩ	± 513 ppm	100.0053 MΩ	53 ppm	50 ppm	

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DC Current Accuracy

3458A set-up: NPLC 500; NDIG 7

Note: The 100 mA and 1 A currents were applied for 5 minutes before measurement.

Applied	Range	Specification (applied \pm limit)	Measured Value	Uncertainty	Status (if applicable)
Front Input Open	100 μ A	\pm 800 pA	-0.00024 μ A	70 pA	
Front Input Open	1 mA	\pm 5 nA	-0.000011 mA	0.20 nA	
Front Input Open	10 mA	\pm 50 nA	-0.000011 mA	2.0 nA	
Front Input Open	100 mA	\pm 500 nA	-0.00004 mA	15 nA	
Front Input Open	1 A	\pm 10 μ A	-0.000015 A	1.9 μ A	
100 μ A	100 μ A	\pm 3.3 nA	99.99986 μ A	0.52 nA	
-100 μ A	100 μ A	\pm 3.3 nA	-99.99986 μ A	0.52 nA	
1 mA	1 mA	\pm 30 nA	0.9999965 mA	5.0 nA	
-1 mA	1 mA	\pm 30 nA	-0.9999979 mA	5.0 nA	
10 mA	10 mA	\pm 0.3 μ A	9.999951 mA	0.050 μ A	
-10 mA	10 mA	\pm 0.3 μ A	-9.999947 mA	0.050 μ A	
100 mA	100 mA	\pm 4.5 μ A	99.99911 mA	0.51 μ A	
-100 mA	100 mA	\pm 4.5 μ A	-99.99949 mA	0.51 μ A	
1 A	1 A	\pm 125 μ A	1.0000216 A	11 μ A	
-1 A	1 A	\pm 125 μ A	-1.0000207 A	11 μ A	

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a coverage probability of approximately 95%.

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