Certificate of Calibration

ISO/IEC 17025:2005 and ANSI/NCSL Z540.1-1994

Certificate Number 1-9431270297-1

Model Number	E4980AL
Manufacturer	Keysight Technologies Inc
Description	Precision LCR Meter
Serial Number	MY54201881
Options Installed	102
Date of Calibration	28 Nov 2017
Procedure	STE-50114717-A.00.05
Temperature	(23 ± 3) ℃
Humidity	(45 ± 25) %RH

Customer
Voltech Instruments Ltd
66 Innovation Dr
Milton Park
ABINGDON OX14 4RQ
United Kingdom

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

This certifies that the equipment has been calibrated using applicable Keysight Technologies procedures and in compliance with ISO/IEC 17025:2005 and ANSI/NCSL Z540.1-1994 (R2002). The quality management system is registered to ISO 9001:2015.

As Received Conditions
The measured values of the equipment were observed in specification at the points tested. Additionally, the expanded measurement uncertainty intervals about the measured values were in specification.

Action Taken
- No corrective actions were necessary.

As Completed Conditions
The measured values of the equipment were observed in specification at the points tested. Additionally, the expanded measurement uncertainty intervals about the measured values were in specification.

Remarks or Special Requirements

This calibration certificate may refer to instruments manufactured by HP, Agilent and Keysight as being manufactured by Keysight Technologies, Inc.

The test limits stated in the report correspond to the published specifications of the equipment, at the points tested.

Based on the customer's request, the next calibration is due on 28 Nov 2018.

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Traceability Information

Technician ID Number 00871990

Measurements are traceable to the International System of Units (SI) via national metrology institutes (www.keysight.com/find/NMI) that are signatories to the CIPM Mutual Recognition Arrangement.

Calibration Equipment Used

Model Number	Model Description	Equipment ID	Cal Due Date	Certificate Number
16380A	Standard capacitors set	UK5358	23 Aug 2019	1-7961662847-1
16380C	C Standard Set	UK10550	16 Aug 2019	1-7961662895-1
3458A	Digital multimeter, 8.5 digit	UK12606	7 Dec 2017	1-8312400108-1
42030A	Four-Terminal Pair Standard Resistor Set	UK12157	25 Sep 2019	1-9159893159-1
5071A	Primary frequency standard	UK13623	22 Feb 2018	1-8543348181-1
53132A	Universal Counter, 225 MHz, 12 digit/s, 150 ps. GPIB, RS232	UK15551	18 Dec 2017	1-7543594361-1

Traceability Table

	Model	Model Description	Equipment ID	Certificate Number	Trace Value
W,R	16380A	Standard capacitors set	UK5358	1-7961662847-1-UKAS:C 0147	Capacitance Dissipation Factor
W,R	16380C	C Standard Set	UK10550	1-7961662895-1-UKAS:C 0147	Capacitance Dissipation Factor
W,R	3458A	Digital multimeter, 8.5 digit	UK12606	1-8312400108-1-UKAS:C 0147	AC Voltage DC Current DC Voltage Resistance
W,R	42030A	Four-Terminal Pair Standard Resistor Set	UK12157	1-9159893159-1-JCSS:0100	AC Resistance
W,R	5071A	Primary frequency standard	UK13623	1-8543348181-1-UKAS:C 0147	Frequency
W,R	53132A	Universal Counter, 225 MHz, 12 digit/s, 150 ps. GPIB, RS232	UK15551	1-7543594361-1-UKAS:C 0147	Frequency

Legend

W - Working Standard The calibration equipment used for the calibration of the Model indicated on the first page of the Certificate of calibration.
R - Reference Standard The Reference Standard (Accredited or NMI-calibrated ETE) used to provide traceability to the SI-Units for the calibration parameters listed.

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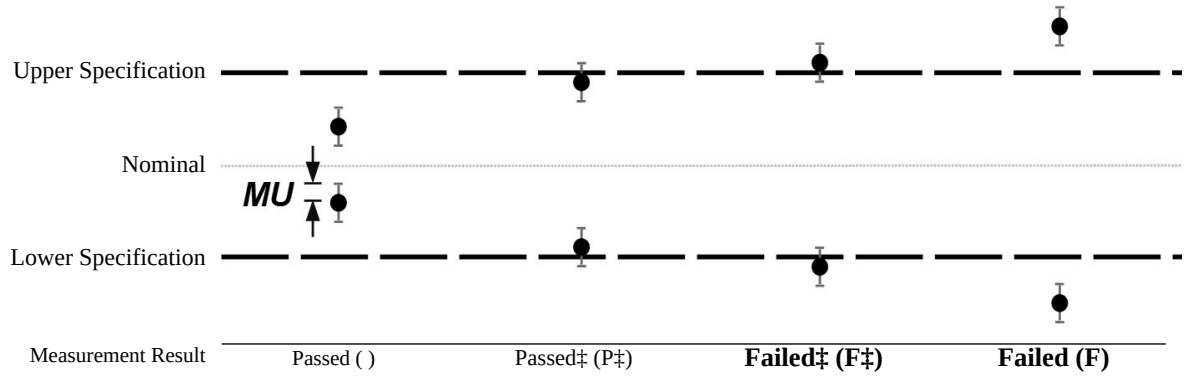
Compliance with Specification

The uncertainty of measurement has been taken into account when determining compliance with specification, as per ILAC-G8:03/2009. If the expanded measurement uncertainty intervals centered about one or more measured values were both in as well as out of specification (upper or lower), it is not possible to state compliance or non-compliance based on a 95% coverage probability for the expanded measurement uncertainty.

An overall statement of compliance for all tests performed as received, and as completed (if any adjustments / repairs were performed) is included at the beginning of this report. Statements of compliance apply only to warranted specifications. When functional verification tests are performed, results are reported in the “Functional Test” section, and do not affect these statements of compliance.
The status summaries relate to the tested item only. A final decision about whether the item's performance actually satisfies requirements of the user can only be made by the user.

Measurement results are reported as:

- Passed ( ) - The measured values of the equipment were observed in specification at the points tested. Additionally, the expanded measurement uncertainty intervals about the measured values were in specification.
- Passed‡ (P‡) - The measured values of the equipment were observed in specification at the points tested. However, a portion of the expanded measurement uncertainty intervals about one or more measured values exceeded specification. Consequently, compliance with specification cannot be declared based on the stated coverage probability.
- Failed‡ (F‡) - One or more measured values of the equipment were observed out of specification at the points tested. However, a portion of the expanded measurement uncertainty intervals about one or more measured values were in specification. Consequently, non-compliance with specification cannot be declared based on the stated coverage probability.
- Failed (F) - One or more measured values of the equipment were observed out of specification at the points tested. Additionally, the expanded measurement uncertainty intervals about one or more measured values were entirely outside the specification.



( ) This result is indicated on the measurement report as a blank space in the column labeled “Status” or “Sts”.
MU = 95% expanded measurement uncertainty.

Uncertainty of Measurement

The uncertainty evaluation has been performed in accordance with ISO/IEC Guide 98-3:2008 (GUM). The reported expanded measurement uncertainty, which corresponds to a coverage probability of approximately 95%, is the standard uncertainty multiplied by the coverage factor k=2. Where this is not the case, coverage factor (k), effective degrees of freedom (veff) and coverage probability (p) are stated.

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Performance Test Results Summary

Test Name	As Received Status
FREQUENCY ACCURACY	Passed
DC BIAS LEVEL ACCURACY	Passed
AC SIGNAL LEVEL ACCURACY	Passed
AC SIGNAL LEVEL MONITOR ACCURACY	Passed
IMPEDANCE TEST ACCURACY-0M	Passed
IMPEDANCE TEST ACCURACY-1M	Passed
IMPEDANCE TEST ACCURACY-2M	Passed
IMPEDANCE TEST ACCURACY-4M	Passed
DCR MEASUREMENT ACCURACY-0M	Passed

FREQUENCY ACCURACY Passed

TEST COND.	MINIMUM	MEASURED	MAXIMUM	UNCERT.	Status
Frequency					
1 MHz	–100.000 Hz	–6.584 Hz	100.000 Hz	0.0038 Hz	

DC BIAS LEVEL ACCURACY Passed

TEST CONDITIONS	MINIMUM	MEASURED	MAXIMUM	UNCERT.	Status
AC Level: 0 Vrms					
All Options, Amp mode: x1					
0 V	–2.000 mV	–0.199 mV	2.000 mV	0.0031 mV	
1.5 V	–3.500 mV	–0.115 mV	3.500 mV	0.018 mV	
2 V	–4.000 mV	–0.183 mV	4.000 mV	0.023 mV	

AC SIGNAL LEVEL ACCURACY Passed

TEST CONDITIONS	MINIMUM	MEASURED	MAXIMUM	UNCERT.	Status
DC LEVEL: 0 V					
1V, 20Hz	–101.000 mV	0.190 mV	101.000 mV	35 mV	
1V,125Hz	–101.000 mV	0.090 mV	101.000 mV	35 mV	
1V, 1kHz	–101.000 mV	0.320 mV	101.000 mV	35 mV	
20mV,1MHz	–3.000 mV	–0.040 mV	3.000 mV	1.3 mV	
0.2V,1MHz	–21.000 mV	–0.285 mV	21.000 mV	7.5 mV	
0.5V,1MHz	–51.000 mV	–0.427 mV	51.000 mV	18 mV	
1V,1MHz	–101.000 mV	–0.357 mV	101.000 mV	35 mV	
2V,1MHz	–201.000 mV	0.970 mV	201.000 mV	70 mV	

AC SIGNAL LEVEL MONITOR ACCURACY Passed

TEST COND.	MINIMUM	MEASURED	MAXIMUM	UNCERT.	Status
1V, 20Hz	–30.500 mV	–0.112 mV	30.500 mV	0.13 mV	
1V,125Hz	–30.500 mV	1.059 mV	30.500 mV	0.11 mV	
1V, 1kHz	–30.500 mV	–0.314 mV	30.500 mV	0.11 mV	
20mV,1MHz	–1.100 mV	0.192 mV	1.100 mV	0.24 mV	
0.2V,1MHz	–6.500 mV	0.326 mV	6.500 mV	2.4 mV	
0.5V,1MHz	–15.500 mV	0.943 mV	15.500 mV	5.9 mV	
1V,1MHz	–30.500 mV	1.223 mV	30.500 mV	12 mV	
2V,1MHz	–60.500 mV	6.260 mV	60.500 mV	24 mV	

IMPEDANCE TEST ACCURACY-0M Passed

TEST CONDITIONS	MINIMUM	MEASURED	MAXIMUM	UNCERT.	Status
Standard:10 pF,SHORT MODE					
0.02V,1MHz Cp	–0.0871 pF	0.0000 pF	0.0871 pF	0.0031 pF	
0.02V,1MHz D	–0.01001	–0.00024	0.01001	0.00026	
Standard:10 pF,MED MODE					
0.3V,100kHz Cp	–0.0241 pF	–0.0006 pF	0.0241 pF	0.00047 pF	
0.3V,100kHz D	–0.00321	–0.00008	0.00321	0.000065	
0.2V,1MHz Cp	–0.0292 pF	–0.0007 pF	0.0292 pF	0.00047 pF	
0.2V,1MHz D	–0.00422	–0.00011	0.00422	0.000065	
0.02V,1MHz Cp	–0.0478 pF	–0.0006 pF	0.0478 pF	0.00067 pF	
0.02V,1MHz D	–0.00608	–0.00011	0.00608	0.000075	
0.3V,1MHz Cp	–0.0241 pF	–0.0006 pF	0.0241 pF	0.00047 pF	
0.3V,1MHz D	–0.00371	–0.00010	0.00371	0.000065	
Standard:100 pF,MED MODE					
0.2V,1MHz Cp	–0.151 pF	0.002 pF	0.151 pF	0.0070 pF	
0.2V,1MHz D	–0.00131	0.00000	0.00131	0.000066	
0.3V,1MHz Cp	–0.101 pF	0.004 pF	0.101 pF	0.0070 pF	
0.3V,1MHz D	–0.00081	0.00000	0.00081	0.000066	
Standard:1000 pF,MED MODE					
0.02V,1kHz Cp	–3.44 pF	–0.04 pF	3.44 pF	0.091 pF	
0.02V,1kHz D	–0.00325	–0.00018	0.00325	0.000091	
0.3V,20Hz Cp	–18.47 pF	0.55 pF	18.47 pF	0.72 pF	
0.3V,20Hz D	–0.01827	–0.00028	0.01827	0.0011	
0.3V,1kHz Cp	–0.95 pF	–0.03 pF	0.95 pF	0.082 pF	
0.3V,1kHz D	–0.00076	–0.00010	0.00076	0.000061	
2V,1kHz Cp	–1.42 pF	–0.03 pF	1.42 pF	0.082 pF	
2V,1kHz D	–0.00123	–0.00010	0.00123	0.000061	
0.02V,1MHz Cp	–3.59 pF	0.01 pF	3.59 pF	0.11 pF	
0.02V,1MHz D	–0.00289	–0.00009	0.00289	0.000069	
0.3V,1MHz Cp	–1.51 pF	0.05 pF	1.51 pF	0.10 pF	
0.3V,1MHz D	–0.00081	–0.00005	0.00081	0.000068	
2V,1MHz Cp	–2.01 pF	0.01 pF	2.01 pF	0.10 pF	
2V,1MHz D	–0.00131	–0.00014	0.00131	0.000067	
Standard:0.1 uF,MED MODE					
0.3V, 120Hz Cp	–0.082 nF	–0.001 nF	0.082 nF	0.0043 nF	
0.3V, 120Hz D	–0.00062	–0.00004	0.00062	0.000033	
0.3V,100kHz Cp	–0.160 nF	0.004 nF	0.160 nF	0.0043 nF	
0.3V,100kHz D	–0.00140	–0.00003	0.00140	0.000033	
Standard:10 uF,MED MODE					
0.3V, 20Hz Cp	–0.0132 uF	–0.0012 uF	0.0132 uF	0.00082 uF	
0.3V, 20Hz D	–0.00112	–0.00018	0.00112	0.000077	
0.3V, 120Hz Cp	–0.084 uF	0.000 uF	0.084 uF	0.77 nF	
0.3V, 120Hz D	–0.00064	–0.00004	0.00064	0.000071	
0.3V, 1kHz Cp	–0.0168 uF	–0.0003 uF	0.0168 uF	0.00079 uF	
0.3V, 1kHz D	–0.00138	–0.00011	0.00138	0.000072	
0.3V, 10kHz Cp	–0.0266 uF	–0.0004 uF	0.0266 uF	0.0018 uF	
0.3V, 10kHz D	–0.00236	0.00003	0.00236	0.00029	

IMPEDANCE TEST ACCURACY-0M (cont.)

TEST CONDITIONS	MINIMUM	MEASURED	MAXIMUM	UNCERT.	Status
0.3V,100kHz Cp	–0.0799 uF	–0.0029 uF	0.0799 uF	0.0075 uF	
0.3V,100kHz D	–0.00779	–0.00058	0.00779	0.00073	
Standard:10 uF,SHORT MODE					
0.3V, 20Hz Cp	–0.0337 uF	–0.0016 uF	0.0337 uF	0.0016 uF	
0.3V, 20Hz D	–0.00317	–0.00017	0.00317	0.00014	
0.3V, 120Hz Cp	–0.0347 uF	0.0000 uF	0.0347 uF	0.00082 uF	
0.3V, 120Hz D	–0.00327	0.00000	0.00327	0.000076	
Standard:1 ohm,MED MODE					
0.3V, 1kHz R	–0.00373 Ω	0.00009 Ω	0.00373 Ω	0.00014 Ω	

IMPEDANCE TEST ACCURACY-1M Passed

TEST CONDITIONS	MINIMUM	MEASURED	MAXIMUM	UNCERT.	Status
Standard:10 pF,MED MODE					
0.3V,100kHz Cp	–0.0247 pF	–0.0013 pF	0.0247 pF	0.00047 pF	
0.3V,100kHz D	–0.00327	–0.00003	0.00327	0.000066	
0.2V,1MHz Cp	–0.0313 pF	–0.0048 pF	0.0313 pF	0.00047 pF	
0.2V,1MHz D	–0.00443	–0.00042	0.00443	0.000065	
0.3V,1MHz Cp	–0.0261 pF	–0.0047 pF	0.0261 pF	0.00047 pF	
0.3V,1MHz D	–0.00391	–0.00043	0.00391	0.000065	
Standard:100 pF,MED MODE					
0.2V,1MHz Cp	–0.167 pF	–0.037 pF	0.167 pF	0.0070 pF	
0.2V,1MHz D	–0.00147	–0.00031	0.00147	0.000065	
0.3V,1MHz Cp	–0.117 pF	–0.036 pF	0.117 pF	0.0071 pF	
0.3V,1MHz D	–0.0097	–0.0003	0.0097	0.00010	
Standard:1000 pF,MED MODE					
0.02V,1kHz Cp	–3.44 pF	–0.01 pF	3.44 pF	0.086 pF	
0.02V,1kHz D	–0.00325	–0.00020	0.00325	0.000085	
0.3V,1kHz Cp	–0.95 pF	–0.02 pF	0.95 pF	0.082 pF	
0.3V,1kHz D	–0.00076	–0.00011	0.00076	0.000062	
2V,1kHz Cp	–1.42 pF	–0.02 pF	1.42 pF	0.082 pF	
2V,1kHz D	–0.00123	–0.00010	0.00123	0.000061	
0.02V,1MHz Cp	–3.74 pF	–0.28 pF	3.74 pF	0.10 pF	
0.02V,1MHz D	–0.00304	–0.00032	0.00304	0.000071	
0.3V,1MHz Cp	–1.66 pF	–0.19 pF	1.66 pF	0.10 pF	
0.3V,1MHz D	–0.00096	–0.00034	0.00096	0.000067	
2V,1MHz Cp	–2.16 pF	–0.23 pF	2.16 pF	0.10 pF	
2V,1MHz D	–0.00146	–0.00035	0.00146	0.000068	

IMPEDANCE TEST ACCURACY-2M Passed

TEST CONDITIONS	MINIMUM	MEASURED	MAXIMUM	UNCERT.	Status
Standard:10 pF,MED MODE					
0.3V,100kHz Cp	–0.0253 pF	–0.0008 pF	0.0253 pF	0.00047 pF	
0.3V,100kHz D	–0.00333	–0.00008	0.00333	0.000065	
0.2V,1MHz Cp	–0.0364 pF	–0.0021 pF	0.0364 pF	0.00047 pF	
0.2V,1MHz D	–0.00494	–0.00031	0.00494	0.000065	
0.3V,1MHz Cp	–0.0311 pF	–0.0018 pF	0.0311 pF	0.00047 pF	
0.3V,1MHz D	–0.00441	–0.00032	0.00441	0.000065	
Standard:100 pF,MED MODE					
0.2V,1MHz Cp	–0.213 pF	–0.012 pF	0.213 pF	0.0070 pF	
0.2V,1MHz D	–0.00193	–0.00020	0.00193	0.000065	
0.3V,1MHz Cp	–0.162 pF	–0.007 pF	0.162 pF	0.0070 pF	
0.3V,1MHz D	–0.00142	–0.00017	0.00142	0.000065	
Standard:1000 pF,MED MODE					
0.02V,1kHz Cp	–3.44 pF	–0.01 pF	3.44 pF	0.11 pF	
0.02V,1kHz D	–0.00325	–0.00021	0.00325	0.00010	
0.3V,1kHz Cp	–0.95 pF	–0.02 pF	0.95 pF	0.081 pF	
0.3V,1kHz D	–0.00076	–0.00010	0.00076	0.000062	
2V,1kHz Cp	–1.42 pF	0.00 pF	1.42 pF	0.10 pF	
2V,1kHz D	–0.00123	–0.00010	0.00123	0.000068	
0.02V,1MHz Cp	–4.19 pF	–0.11 pF	4.19 pF	0.11 pF	
0.02V,1MHz D	–0.00349	–0.00039	0.00349	0.000076	
0.3V,1MHz Cp	–2.11 pF	–0.08 pF	2.11 pF	0.10 pF	
0.3V,1MHz D	–0.00141	–0.00035	0.00141	0.000067	
2V,1MHz Cp	–2.61 pF	–0.10 pF	2.61 pF	0.10 pF	
2V,1MHz D	–0.00191	–0.00041	0.00191	0.000068	

IMPEDANCE TEST ACCURACY-4M Passed

TEST CONDITIONS	MINIMUM	MEASURED	MAXIMUM	UNCERT.	Status
Standard:10 pF,MED MODE					
0.3V,100kHz Cp	–0.0265 pF	0.0002 pF	0.0265 pF	0.00047 pF	
0.3V,100kHz D	–0.00345	–0.00021	0.00345	0.000066	
0.2V,1MHz Cp	–0.0556 pF	–0.0027 pF	0.0556 pF	0.00047 pF	
0.2V,1MHz D	–0.00686	–0.00103	0.00686	0.000065	
0.3V,1MHz Cp	–0.0502 pF	–0.0023 pF	0.0502 pF	0.00047 pF	
0.3V,1MHz D	–0.00632	–0.00100	0.00632	0.000065	
Standard:100 pF,MED MODE					
0.2V,1MHz Cp	–0.394 pF	–0.013 pF	0.394 pF	0.0070 pF	
0.2V,1MHz D	–0.00374	–0.00111	0.00374	0.000066	
0.3V,1MHz Cp	–0.343 pF	–0.010 pF	0.343 pF	0.0070 pF	
0.3V,1MHz D	–0.00323	–0.00107	0.00323	0.000065	
Standard:1000 pF,MED MODE					
0.02V,1kHz Cp	–3.45 pF	0.07 pF	3.45 pF	0.10 pF	

IMPEDANCE TEST ACCURACY-4M (cont.)

TEST CONDITIONS	MINIMUM	MEASURED	MAXIMUM	UNCERT.	Status
0.02V,1kHz D	–0.00326	–0.00011	0.00326	0.00011	
0.3V,1kHz Cp	–0.95 pF	0.00 pF	0.95 pF	0.081 pF	
0.3V,1kHz D	–0.00076	–0.00010	0.00076	0.000062	
2V,1kHz Cp	–1.42 pF	0.00 pF	1.42 pF	0.081 pF	
2V,1kHz D	–0.00123	–0.00010	0.00123	0.000061	
0.02V,1MHz Cp	–6.00 pF	–0.05 pF	6.00 pF	0.11 pF	
0.02V,1MHz D	–0.00530	–0.00113	0.00530	0.000082	
0.3V,1MHz Cp	–3.92 pF	–0.06 pF	3.92 pF	0.10 pF	
0.3V,1MHz D	–0.00322	–0.00113	0.00322	0.000082	
2V,1MHz Cp	–4.41 pF	–0.05 pF	4.41 pF	0.10 pF	
2V,1MHz D	–0.00371	–0.00116	0.00371	0.000068	

DCR MEASUREMENT ACCURACY-0M Passed

TEST COND.	MINIMUM	MEASURED	MAXIMUM	UNCERT.	Status
1 Ω, R	–0.0083 Ω	–0.0006 Ω	0.0083 Ω	0.00077 Ω	
1 kΩ, R	–0.0033 kΩ	0.0000 kΩ	0.0033 kΩ	0.00017 kΩ	
100 kΩ, R	–0.430 kΩ	0.004 kΩ	0.430 kΩ	0.013 kΩ	