

Supplementary Information



Standards Laboratory Calibration

Order Number 1-██████████-1

Model Number 8481A
Manufacturer Agilent Technologies
Description Power Sensor, 10 MHz to 18 GHz, -30 to +20 dBm
Serial Number ██████████

Customer
██████████
██████████
██████████

Options Installed H84

Date of Calibration 16 Jul 2015
Procedure AGT_8481A PN 5011-4424
Temperature (23 ± 1) °C
Humidity (45 ± 10) %RH

Location of Calibration
Keysight Technologies UK Limited
610 Wharfedale Road
IQ Winnersh
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
11667A	DC-18 GHz power splitter, type N, 50 ohm	UK15643	17 Dec 2015	1-██████████-1
8481A	Power Sensor, 10 MHz to 18 GHz, -30 to +20 dBm	UK14974	13 Mar 2018	1-██████████-1
8481A	Power Sensor, 10 MHz to 18 GHz, -30 to +20 dBm	UK15610	9 May 2017	1-██████████-1
85032B	50-Ohm Type-N calibration kit	UK15364	9 Apr 2016	1-██████████-1
85054B	Standard mechanical calibration kit, DC to 18 GHz, type-N	UK12225	14 May 2016	1-██████████-1
8710-1766	Wrench - Torque, 12lb-in, 3/4 in, Open End	UK13198	8 Jan 2018	1-██████████-1
E4417A	Power Meter - EPM-P series, dual channel	UK15474	20 May 2017	1-██████████-1
E5071C	ENA Series Network analyzer	UK15587	25 Sep 2015	1-██████████-1
E8257D	PSG analog signal generator	UK15714	18 Dec 2015	1-██████████-1
E8364C	10 MHz to 50 GHz vector network analyzer; 2 port; 4 receiver	UK15257	10 Dec 2015	1-██████████-1
IPIMMS N	N-Type Ipimms Cal Kit	UK15620	27 Nov 2016	1-██████████-1
N5230C	PNA-L network analyzer	UK15727	9 Sep 2015	1-██████████-1

Keysight Technologies UK Limited
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Edgar Leckel - European Operations Manager

CERTIFICATE OF CALIBRATION



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CERTIFICATE
NUMBER

1-SAMPLE-1A

Approved Signatory

Chris Hawe

Date of Issue:	20 July 2015	Page 1 of 4 pages	
Instrument Description:	50 Ω Power Sensor		
Instrument Manufacturer:	Agilent Technologies		
Model Number:	8481A (Option H84)		
Serial Number:	██████████		
Reference Number:	1-██████████-1		
Customer:	██████████		
Date of Calibration:	16 July 2015		
Ambient Temperature:	23 \pm 1 $^{\circ}$ C	Relative Humidity:	45 \pm 10 %

Remarks:

The on-receipt calibration status of the power sensor is recorded in this certificate, the instrument was returned in this condition. The power sensors performance conforms to the specification at the points measured, with due allowance having been made for measurement uncertainties.

The reported calibration factor values are the arithmetic mean of at least 5 separate measurements.

Specifications taken from Agilent 8480 Series Coaxial Power Sensors Operating and Service Manual, P/N 08481-90173 dated May 2004.

The uncertainty in the measurement frequency is estimated not to exceed ± 1 part in 10^{10} .

Test location

<input checked="" type="radio"/> Permanent lab	<input type="radio"/> Mobile lab	<input type="radio"/> Customer's building
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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.

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Reference calibration factor = 99.0 %

Calibration Factor		
Measurement Frequency	Measured Value	Measurement Uncertainty
0.01 GHz	99.0 %	± 0.7 %
0.03 GHz	99.0 %	± 0.6 %
0.05 GHz	99.0 %	Ref
0.10 GHz	99.0 %	± 0.6 %
0.30 GHz	98.8 %	± 0.7 %
0.50 GHz	98.4 %	± 0.7 %
0.80 GHz	98.4 %	± 0.7 %
1.00 GHz	97.7 %	± 0.7 %
1.20 GHz	97.9 %	± 0.7 %
1.50 GHz	97.9 %	± 0.7 %
2.00 GHz	97.5 %	± 0.7 %
3.00 GHz	97.2 %	± 0.7 %
4.00 GHz	96.9 %	± 0.7 %
5.00 GHz	96.6 %	± 0.8 %
6.00 GHz	96.2 %	± 0.8 %
7.00 GHz	95.7 %	± 0.8 %
8.00 GHz	95.3 %	± 1.0 %
9.00 GHz	94.6 %	± 1.3 %
10.00 GHz	94.3 %	± 1.3 %
11.00 GHz	93.8 %	± 1.1 %
12.00 GHz	93.3 %	± 1.1 %
12.40 GHz	93.2 %	± 1.1 %
13.00 GHz	92.9 %	± 1.1 %
14.00 GHz	92.3 %	± 1.1 %
15.00 GHz	91.6 %	± 1.2 %
16.00 GHz	91.7 %	± 1.3 %
17.00 GHz	90.6 %	± 1.8 %
18.00 GHz	89.6 %	± 3.1 %

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Measured S_{11} [Note 1]					
Measurement Frequency	Real	Imaginary	VRC Magnitude	Uncert. [Note 2]	k Factor
0.01 GHz	-0.00598	-0.05769	0.058	± 0.0054	2.0
0.03 GHz	-0.01215	-0.01953	0.023	± 0.0053	2.0
0.05 GHz	-0.01300	-0.01086	0.017	± 0.00349	2.5
0.10 GHz	-0.01318	-0.00271	0.013	± 0.00340	2.5
0.30 GHz	-0.00938	0.00831	0.013	± 0.00330	2.5
0.50 GHz	-0.00295	0.01110	0.011	± 0.00328	2.5
0.80 GHz	0.00732	0.01200	0.014	± 0.00326	2.5
1.00 GHz	0.01107	0.00447	0.012	± 0.00357	2.5
1.20 GHz	0.01110	0.00123	0.011	± 0.00353	2.5
1.50 GHz	0.01152	-0.00548	0.013	± 0.00349	2.5
2.00 GHz	0.00177	-0.01356	0.014	± 0.00344	2.5
3.00 GHz	-0.01215	0.00036	0.012	± 0.00340	2.5
4.00 GHz	0.00032	0.00925	0.009	± 0.00336	2.5
5.00 GHz	0.00744	0.00231	0.008	± 0.00334	2.5
6.00 GHz	0.00559	-0.00842	0.010	± 0.00335	2.5
7.00 GHz	-0.01259	-0.00630	0.014	± 0.00334	2.5
8.00 GHz	-0.00259	0.01678	0.017	± 0.00335	2.5
9.00 GHz	0.01742	-0.00397	0.018	± 0.00340	2.5
10.00 GHz	-0.00882	-0.01054	0.014	± 0.00337	2.5
11.00 GHz	0.00193	0.00410	0.005	± 0.00337	2.5
12.00 GHz	-0.00811	-0.01137	0.014	± 0.00340	2.5
12.40 GHz	-0.01850	-0.00124	0.019	± 0.00336	2.5
13.00 GHz	-0.00716	0.02126	0.022	± 0.00334	2.5
14.00 GHz	0.01922	-0.01265	0.023	± 0.00337	2.5
15.00 GHz	-0.03553	0.00453	0.036	± 0.00338	2.5
16.00 GHz	0.05251	0.03205	0.062	± 0.00341	2.5
17.00 GHz	-0.01560	-0.08317	0.085	± 0.00352	2.5
18.00 GHz	-0.05653	0.08429	0.101	± 0.00348	2.5

1. Measurements from 50 MHz and above are made using iPIMMS.

2. The uncertainties below 50 MHz relate to the VRC magnitude. Otherwise it applies to the Real & Imaginary components.

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Input Voltage Reflection Coefficient and Reflection Phase

Calculated Voltage Reflection Coefficient Magnitude and Phase					
Measurement Frequency	Magnitude	Specification	Uncertainty [Note 1]	Phase	Uncertainty [Note 1]
0.01 GHz	0.058	≤ 0.167	± 0.005	-95.92 °	± 5.34 °
0.03 GHz	0.023	≤ 0.083	± 0.005	-121.88 °	± 13.32 °
0.05 GHz	0.017	≤ 0.048	± 0.003	-140.13 °	± 9.33 °
0.10 GHz	0.013	≤ 0.048	± 0.003	-168.40 °	± 11.74 °
0.30 GHz	0.013	≤ 0.048	± 0.003	138.48 °	± 12.01 °
0.50 GHz	0.011	≤ 0.048	± 0.003	104.86 °	± 12.99 °
0.80 GHz	0.014	≤ 0.048	± 0.003	58.60 °	± 10.45 °
1.00 GHz	0.012	≤ 0.048	± 0.003	21.99 °	± 13.63 °
1.20 GHz	0.011	≤ 0.048	± 0.003	6.33 °	± 15.01 °
1.50 GHz	0.013	≤ 0.048	± 0.003	-25.42 °	± 12.46 °
2.00 GHz	0.014	≤ 0.048	± 0.003	-82.56 °	± 11.40 °
3.00 GHz	0.012	≤ 0.083	± 0.003	178.30 °	± 12.77 °
4.00 GHz	0.009	≤ 0.083	± 0.003	88.04 °	± 16.62 °
5.00 GHz	0.008	≤ 0.083	± 0.003	17.26 °	± 20.19 °
6.00 GHz	0.010	≤ 0.083	± 0.003	-56.43 °	± 15.08 °
7.00 GHz	0.014	≤ 0.083	± 0.003	-153.41 °	± 11.02 °
8.00 GHz	0.017	≤ 0.083	± 0.003	98.79 °	± 8.93 °
9.00 GHz	0.018	≤ 0.083	± 0.003	-12.83 °	± 8.67 °
10.00 GHz	0.014	≤ 0.083	± 0.003	-129.92 °	± 11.07 °
11.00 GHz	0.005	≤ 0.083	± 0.003	64.82 °	± 35.43 °
12.00 GHz	0.014	≤ 0.083	± 0.003	-125.50 °	± 11.24 °
12.40 GHz	0.019	≤ 0.083	± 0.003	-176.15 °	± 8.27 °
13.00 GHz	0.022	≤ 0.123	± 0.003	108.62 °	± 6.72 °
14.00 GHz	0.023	≤ 0.123	± 0.003	-33.36 °	± 6.61 °
15.00 GHz	0.036	≤ 0.123	± 0.003	172.73 °	± 4.29 °
16.00 GHz	0.062	≤ 0.123	± 0.003	31.40 °	± 2.50 °
17.00 GHz	0.085	≤ 0.123	± 0.003	-100.63 °	± 1.90 °
18.00 GHz	0.101	≤ 0.123	± 0.003	123.85 °	± 1.56 °

1. The uncertainties reported for the iPIMMS measurements have been computed by Monte Carlo Simulation for 95% coverage probability.