



CERTIFICATE OF ACCREDITATION

ANSI-ASQ National Accreditation Board

500 Montgomery Street, Suite 625, Alexandria, VA 22314, 877-344-3044

This is to certify that

Keysight Technologies (Malaysia) SDN BHD
Phase 3, Bayan Lepas Free Industrial Zone
11900 Bayan Lepas, Penang, Malaysia

has been assessed by ANAB and meets the requirements of international standard

ISO/IEC 17025:2005

and national standards

ANSI/NCSL Z540-1-1994 (R2002) AND
ANSI/NCSL Z540.3-2006 (R2013)

while demonstrating technical competence in the field of

CALIBRATION

Refer to the accompanying Scope of Accreditation for information regarding the types of calibrations to which this accreditation applies.

AC-1928
Certificate Number


ANAB Approval

Certificate Valid: 02/05/2018-03/11/2020
Version No. 006 Issued: 02/05/2018



This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. 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 April 2017).



**SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005,
ANSI/NCSL Z540-1-1994 (R2002) AND ANSI/NCSL Z540.3-2006 (R2013)**

Keysight Technologies (Malaysia) SDN BHD

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CALIBRATION

Valid to: **March 11, 2020**

Certificate Number: **AC-1928**

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Power Sources Fitted with female Type-N connectors	1 mW at 50 MHz	2.2 μ W	Thermistor Mount 478A Direct measurement (1 mW 50 MHz Reference Source Calibration)
Passive Devices Scalar Attenuation, Measure	1.01 kHz to 1 MHz 0 dB to 40 dB 40 dB to 80 dB 80 dB to 110 dB	0.009 dB 0.022 dB 0.033 dB	PRT-73 Ratio Transformer 1 kHz intermediate frequency substitution method
	(1 to 80) MHz 0 dB to 40 dB 40 dB to 80 dB 80 dB to 110 dB	0.005 dB 0.01 dB 0.03 dB	
	80 MHz to 6 GHz 0 dB to 40 dB 40 dB to 80 dB 80 dB to 110 dB	0.01 dB 0.021 dB 0.032 dB	
Passive Devices Scattering Parameter: Reflection coefficient (linear)	10 kHz to 300 kHz 0 to 0.1 0.1 to 0.5 0.5 to 1.0	0.002 2 0.002 8 0.005 5	Measure using 8753ES Network Analyzer, 85054B Calibration Kit Direct measurement
	300 kHz to 6 GHz 0 to 0.1 0.1 to 0.5 0.5 to 1.0	0.001 8 0.002 4 0.005 2	



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Passive Devices Scattering Parameter: Reflection coefficient (linear)	45 MHz to 50 GHz (See Matrix A)	(See Matrix A)	Measure using E8364B/C Network Analyzer Direct Measurement
Passive Devices Scattering Parameter: Transmission coefficient	10 kHz to 30 kHz 0 dB to 10 dB 10 dB to 20 dB 20 dB to 30 dB	0.062 dB 0.072 dB 0.13 dB	Measure using 8753ES Network Analyzer, 85054B Calibration Kit Direct Measurement
	30 kHz to 6 GHz 0 dB to 10 dB 10 dB to 20 dB 20 dB to 30 dB 30 dB to 40 dB 40 dB to 50 dB 50 dB to 60 dB 60 dB to 70 dB 70 dB to 80 dB	0.057 dB 0.06 dB 0.061 dB 0.073 dB 0.09 dB 0.098 dB 0.15 dB 0.38 dB	
	45 MHz to 50 GHz (See Matrix B)	(See Matrix B)	
Power Sensor, Calibration Factors	100 pW to 1 μW (10 to 50) MHz 50 MHz to 18 GHz (18 to 26.5) GHz (26.5 to 50) GHz	0.35 % 0.35 % 1.3 % 1.3 %	Reference to 1 mW at 50 MHz Substitution measurement
	(1 to 100) μW (9 to 100) kHz 100 kHz to 10 MHz (10 to 50) MHz 50 MHz to 4.2 GHz (4.2 to 18) GHz (18 to 26.5) GHz (26.5 to 50) GHz	0.4 % 0.3 % 0.3 % 0.3 % 0.32 % 1 % 1.3 %	



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Power Sensor, Calibration Factors	100 μ W to 10 mW		Reference to 1 mW at 50 MHz Substitution measurement
	(9 to 100) kHz	0.4 %	
	100 kHz to 10 MHz	0.3 %	
	(10 to 50) MHz	0.3 %	
	50 MHz to 4.2 GHz	0.3 %	
	(4.2 to 18) GHz	0.32 %	
(18 to 26.5) GHz	1 %		
(26.5 to 50) GHz	1.3 %		
Power Sensor, Calibration Factors	(10 to 100) mW		Reference to 1 mW at 50 MHz Substitution measurement
	(9 to 100) kHz	0.4 %	
	100 kHz to 10 MHz	0.3 %	
	(10 to 50) MHz	0.3 %	
	50 MHz to 4.2 GHz	0.3 %	
	(4.2 to 18) GHz	0.32 %	
(18 to 26.5) GHz	1 %		
(26.5 to 50) GHz	1.3 %		
Power Sensor, Calibration Factors 75 Ω System	100 mW to 3 W		
	100 kHz to 10 MHz	0.3 %	
	10 MHz to 4.2 GHz	0.3 %	
(4.2 to 18) GHz	0.33 %		
Power Sensor, Calibration Factors 75 Ω System	1 μ W to 100 mW		
	100 kHz to 2 GHz	0.97 %	
Scattering Parameter: Reflection Coefficient, Γ	$-1 \leq \text{Re}\{\Gamma\} \leq 1$ $-1 \leq \text{Im}\{\Gamma\} \leq 1$ constrained by: $0 \leq \Gamma \leq 1$		Measure using iPIMMS Substitution measurement
Passive Devices fitted with Type-N connectors	45 MHz to 18 GHz	0.003	
Passive Devices fitted 3.5 mm connectors	45 MHz to 33 GHz	0.004	



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scattering Parameter: Transmission Coefficient, T Passive Devices fitted with Type-N connectors	$-1 \leq \text{Re}\{T\} \leq 1$ $-1 \leq \text{Im}\{T\} \leq 1$ constrained by: $0 \leq T \leq 1$ 45 MHz to 18 GHz 0 dB to 10 dB 10 dB to 20 dB 20 dB to 30 dB 30 dB to 40 dB 40 dB to 50 dB 50 dB to 60 dB 60 dB to 70 dB 70 dB to 80 dB 80 dB to 90 dB 90 dB to 100 dB	0.000 2 dB 0.008 8 dB 0.018 dB 0.027 dB 0.037 dB 0.056 dB 0.12 dB 0.34 dB 1 dB 2.9 dB	Measure using iPIMMS Substitution measurement
Scattering Parameter: Transmission Coefficient, T Passive Devices fitted 3.5 mm connectors	$-1 \leq \text{Re}\{T\} \leq 1$ $-1 \leq \text{Im}\{T\} \leq 1$ constrained by: $0 \leq T \leq 1$ 45 MHz to 33 GHz 0 dB to 10 dB 10 dB to 20 dB 20 dB to 30 dB 30 dB to 40 dB 40 dB to 50 dB 50 dB to 60 dB 60 dB to 70 dB 70 dB to 80 dB 80 dB to 90 dB 90 dB to 100 dB	0.000 2 dB 0.008 8 dB 0.018 dB 0.027 dB 0.037 dB 0.056 dB 0.12 dB 0.34 dB 1 dB 2.9 dB	Substitution measurement
Signal Sources – Absolute RF Power in Coaxial	(See Matrix C)	(See Matrix C)	Direct measurement Power Sensor Power Meter
Signal Sources – RF Power Flatness in Coaxial Line	(See Matrix D)	(See Matrix D)	Direct measurement Power Sensor Power Meter



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Signal Sources -Harmonic Content	Fundamental Frequency 1 MHz to 25 GHz (0 to 10) dBm Harmonic Frequency 2 MHz to 50 GHz -110 dBm to 0 dBm	0.51 dB	Signal analyzer E4448A Direct measurement
Signal Sources - Pulse Time Parameters Rise/Fall Time	(0 to 10) dBm 10 MHz to 50 GHz	86 ps	Oscilloscope mainframe 86100C Electrical module 86117A Direct measurement
Signal Sources -Modulation Frequency Modulation Peak Frequency Deviation	-18 to 30 dBm f _c : 250 kHz to 10 MHz f _m : 20 Hz to 10 kHz Δf: 200 Hz to 40 kHz β > 0.2 f _c : 250 kHz to 10 MHz f _m : 20 Hz to 10 kHz Δf: 200 Hz to 40 kHz β > 1.2 f _c : 10 MHz to 6.6 GHz f _m : 50 Hz to 200 kHz Δf: 250 Hz to 400 kHz β > 0.2 f _c : 10 MHz to 6.6 GHz f _m : 50 Hz to 200 kHz Δf: 250 Hz to 400 kHz β > 0.45 f _c : 6.6 GHz to 13.2 GHz f _m : 50 Hz to 200 kHz Δf: 250 Hz to 400 kHz β > 0.2	0.015 Hz/Hz 0.01 Hz/Hz 0.015 Hz/Hz 0.01 Hz/Hz 0.025 Hz/Hz	Signal analyzer E4448A f _c = Carrier Frequency f _m = Modulation Rate Δf=Peak Deviation β = Δf / f _m Direct measurement



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Signal Sources -Modulation Frequency Modulation Peak Frequency Deviation	-18 to 30 dBm f_c : 6.6 GHz to 13.2 GHz f_m : 50 Hz to 200 kHz Δf : 250 Hz to 400 kHz $\beta > 8$	0.01 Hz/Hz	Signal analyzer E4448A f_c = Carrier Frequency f_m = Modulation Rate Δf =Peak Deviation $\beta = \Delta f / f_m$ Direct measurement
	f_c : 13.2 GHz to 31.15 GHz f_m : 50 Hz to 200 kHz Δf : 250 Hz to 400 kHz $\beta > 0.2$	0.038 Hz/Hz	
	f_c : (13.2 to 31.15) GHz f_m : 50 Hz to 200 kHz Δf : 250 Hz to 400 kHz $\beta > 16$	0.01 Hz/Hz	
	f_c : (31.15 to 50) GHz f_m : 50 Hz to 200 kHz Δf : 250 Hz to 400 kHz $\beta > 0.2$	0.085 Hz/Hz	
	f_c : (31.15 to 50) GHz f_m : 50 Hz to 200 kHz Δf : 250 Hz to 400 kHz $\beta > 32$	0.01 Hz/Hz	
Signal Sources Amplitude Modulation Depth	-18 to 30 dBm f_m : 50 Hz to 100 kHz f_c : 100 kHz to 10 MHz Depth: 5 % to 99 % f_c : 10 MHz to 3 GHz Depth: 20 % to 99 % f_c : 10 MHz to 3 GHz Depth: 5 % to 20 % f_c : (3 to 26.5) GHz Depth: 20 % to 99 %	0.007 5 %/% 0.005 %/% 0.025 %/% 0.015 %/%	Signal analyzer E4448A f_c = Carrier Frequency f_m = Modulation Rate Direct measurement



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Signal Sources Amplitude Modulation Depth	-18 to 30 dBm f_m : 50 Hz to 100 kHz	0.045 %/%	Signal analyzer E4448A f_c = Carrier Frequency f_m = Modulation Rate Direct measurement
	f_c : (3 to 26.5) GHz Depth: 5 % to 20 %	0.019 %/%	
	f_c : (26.5 to 31.15) GHz Depth: 20 % to 99 %	0.068 %/%	
	f_c : (26.5 to 31.15) GHz Depth: 5 % to 20 %	0.06 %/%	
	f_c : (31.15 to 50) GHz Depth: 5 % to 20 %	0.26 %/%	
	f_c : (31.15 to 50) GHz Depth: 5 % to 20 %	0.26 %/%	
Phase Modulation Peak phase deviation	-18 to 30 dBm f_c : 100 kHz to 6.6 GHz $\Delta\Phi > 0.7$ rad	0.01 rad/rad	Signal analyzer E4448A f_c = Carrier Frequency $\Delta\Phi$ = Phase Deviation Direct measurement
	f_c : 100 kHz to 6.6 GHz $\Delta\Phi > 0.3$ rad	0.03 rad/rad	
	f_c : (6.6 to 13.2) GHz $\Delta\Phi > 2.0$ rad	0.01 rad/rad	
	f_c : (6.6 to 13.2) GHz $\Delta\Phi > 0.6$ rad	0.03 rad/rad	
	f_c : (13.2 to 26.5) GHz $\Delta\Phi > 4.0$ rad	0.01 rad/rad	
	f_c : (13.2 to 26.5) GHz $\Delta\Phi > 1.2$ rad	0.03 rad/rad	
	f_c : (26.5 to 31.15) GHz $\Delta\Phi > 4.0$ rad	0.01 rad/rad	



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Modulation Peak phase deviation	-18 to 30 dBm f _c : (26.5 to 31.15) GHz ΔΦ > 1.3 rad f _c : (31.15 to 50) GHz ΔΦ > 8 rad f _c : (31.15 to 50) GHz ΔΦ > 2.4 rad	 0.03 rad/rad 0.01 rad/rad 0.03 rad/rad	Signal analyzer E4448A f _c = Carrier Frequency ΔΦ = Phase Deviation Direct measurement
Phase Modulation Modulation Rate Amplitude Modulation Rate Frequency Modulation Rate Phase Modulation Rate	-18 to 30 dBm 100 kHz ≤ f _c < 50 GHz Depth ≥ 20% f _m ≤ 100 kHz β ≥ 0.01 f _m ≤ 200 kHz β ≥ 0.01 f _m ≤ 20 kHz	 0.062 Hz 0.062 Hz 0.062 Hz	Signal analyzer E4448A β = Δf / f _m f _m = Modulation Rate Direct measurement
Signal Sources -Modulation Distorsion Amplitude Modulation Distorsion	0.01% to 100% f _m : 20 Hz to 1 kHz f _c : 100 kHz to 10 MHz Depth: > 1 % Depth: > 3 % f _m : 20 Hz to 1 kHz f _c : 10 MHz to 26.5 GHz Depth: > 1 % Depth: > 3 % f _m : 20 Hz to 1 kHz f _c : (26.5 to 50) GHz Depth: > 1 % Depth: > 3 % Depth: > 5 %	 0.001 2 %/% + 0.8 % 0.001 2 %/% + 0.3 % 0.001 2 %/% + 1 % 0.001 2 %/% + 0.4 % 0.001 2 %/% + 6.2 % 0.001 2 %/% + 2 % 0.001 2 %/% + 1.5 %	Signal analyzer E4448A f _c =Carrier Frequency f _m = Modulation Rate Direct measurement



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Signal Sources Phase Modulation Distortion	0.01% to 100% f _c : 1 MHz to 6.6 GHz f _m : (20 to 500) Hz ΔΦ > 0.8 rad ΔΦ ≥ 2.5 rad	0.001 2 %/% + 0.3 % 0.001 2 %/% + 0.1 %	Signal analyzer E4448A f _c =Carrier Frequency f _m = Modulation Rate Direct measurement
	f _c : 1 MHz to 6.6 GHz f _m : 500 Hz to 1 kHz ΔΦ > 0.4 rad ΔΦ ≥ 1.0 rad	0.001 2 %/% + 0.3 % 0.001 2 %/% + 0.1 %	
Signal Sources Phase Modulation Distortion	0.01% to 100% f _c : (6.6 to 13.2) GHz f _m : (20 to 500) Hz ΔΦ > 1.8 rad ΔΦ ≥ 5.5 rad	0.001 2 %/% + 0.3 % 0.001 2 %/% + 0.1 %	Signal analyzer E4448A f _c =Carrier Frequency f _m = Modulation Rate Direct measurement
	f _c : (13.2 to 31.15) GHz f _m : (20 to 500) Hz ΔΦ > 3.5 rad ΔΦ ≥ 10.0 rad	0.001 2 %/% + 0.3 % 0.001 2 %/% + 0.1 %	
	0.01% to 100% f _c : (13.2 to 31.15) GHz f _m : 500 Hz to 1 kHz ΔΦ > 1.2 rad ΔΦ ≥ 4.0 rad	0.001 2 %/% + 0.3 % 0.001 2 %/% + 0.1 %	
	f _c : (31.15 to 50) GHz f _m : (20 to 500) Hz ΔΦ > 7.5 rad ΔΦ ≥ 19.0 rad	0.001 2 %/% + 0.3 % 0.001 2 %/% + 0.1 %	
	f _c : (31.15 to 50) GHz f _m : 500 Hz to 1 kHz ΔΦ > 3.0 rad ΔΦ ≥ 8.0 rad	0.001 2 %/% + 0.3 % 0.001 2 %/% + 0.1 %	



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<p>Signal Sources -Digital Modulation Carrier: 2 MHz to 2.65 GHz</p> <p>Error Vector Magnitude for Modulation Types: MSK, GMSK, BPSK, DQPSK, $\pi/4$DQPSK, 8PSK, 16QAM and 32QAM, QPSK</p> <p>Phase Error for Modulation Types: MSK, GMSK, BPSK, DQPSK, $n/4$DQPSK, 8PSK, 16QAM and 32QAM, QPSK</p> <p>Error Vector Magnitude for FSK Modulation</p>	<p>Mod Frequency Span:</p> <p>(1 to 100) kHz 100 kHz to 1 MHz 1 MHz to 2.65 GHz</p> <p>(1 to 100) kHz (0.1 to 1) MHz 1 MHz to 2.65 GHz</p> <p>Mod Frequency: 3.2 kHz 1.152 kHz</p>	<p>0.31 % rms 0.51 % rms 1.1 % rms</p> <p>0.18 ° rms 0.35 ° rms 0.58 ° rms</p> <p>0.51 % rms 1.6 % rms</p>	<p>Vector signal analyzer 89441A Direct measurement</p>
<p>Signal Sources</p> <p>Frequency Modulation Distortion</p>	<p>0.01% to 100%</p> <p>f_c: (6.6 to 13.2) GHz f_m: 20 Hz to 1 kHz $\Delta f > 2.3$ kHz $\Delta f \geq 4.5$ kHz</p> <p>f_c: (13.2 to 31.15) GHz f_m: 20 Hz to 1 kHz $\Delta f > 2.7$ kHz $\Delta f \geq 6.0$ kHz</p> <p>f_c: (31.15 to 50) GHz f_m: 20 Hz to 1 kHz $\Delta f > 4.0$ kHz $\Delta f \geq 12.0$ kHz</p>	<p>0.001 2 %/% + 0.3 % 0.001 2 %/% + 0.1 %</p> <p>0.001 2 %/% + 0.3 % 0.001 2 %/% + 0.1 %</p> <p>0.001 2 %/% + 0.3 % 0.001 2 %/% + 0.1 %</p>	<p>Signal analyzer E4448A f_c =Carrier Frequency f_m = Modulation Rate Direct measurement</p>



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Signal Sources – Modulation Distortion	0.01% to 100% f _c : 1 MHz to 6.6 GHz f _m : 20 Hz to 1 kHz Δf: 500 Hz to 2 kHz Δf ≥ 2.0 kHz	0.001 2 %/% + 0.3 % 0.001 2 %/% + 0.1 %	Signal analyzer E4448A f _c =Carrier Frequency f _m = Modulation Rate Direct measurement
Signal Sources – Phase Noise	Power level: (0 to 15) dBm f _c : 50 kHz to 1.6 GHz f offset: 0.1 Hz to 1 MHz Power level: (0 to 15) dBm f _c : (1.2 to 26.5) GHz f offset: 0.1 Hz to 1 MHz	2.4 dBc/Hz 2.4 dBc/Hz	Phase Noise Test Set N5500A Reciprocity measurement
Signal Analyzers – Absolute RF Power in Coaxial Line	(See Matrix E)	(See Matrix E)	Signal Sources, Power Splitters, Power Meters, Power Sensors Direct measurement
Signal Analyzers – Relative RF Power in Coaxial Line	0 dB to 70 dB 70 dB to 110 dB Max power level: 10 dBm 50 MHz to 2 GHz	0.013 dB 0.04 dB	Signal Source E8257D, Step Attenuators Direct measurement
Signal Analyzers, Frequency Counters – Frequency	100 MHz to 50 GHz	1.4 × 10 ⁻¹¹ Hz/Hz	Signal Source E8257D, Frequency Standard 5071A Differential measurement
Signal Analyzers – Phase Noise	Carrier frequency: 1 GHz Offset frequency: 100 Hz to 10 MHz	0.36 dB	Signal Source 500-13438 Source phase noise: -107 to -167 dBc/Hz Direct measurement



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
CISPR 16-1-1 Detectors (Response of Quasi-peak, peak, average, RMS) at 50 Ω system Pulse Spectral Density	13.50 μVs	0.27 dB	Direct measurement PRF ¹ = pulse repetitive frequency Pulse Generator IGUU 2916
	1.350 μVs	0.26 dB	
	Band A (9 to 150) kHz PRF ¹ : 25 Hz		
	0.3160 μVs	0.26 dB	
	0.0316 μVs	0.26 dB	
	Band B 150kHz to 30 MHz PRF ¹ : 100 Hz		
	0.0440 μVs	0.28 dB	
	Band CD (30 to 480) MHz	0.33 dB	
	Band CD 500 MHz to 1 GHz PRF ¹ : 100 Hz		
	0.0044 μVs	0.27 dB	
Band CD (30 to 480) MHz	0.32 dB		
Band CD 500 MHz to 1 GHz PRF ¹ : 100 Hz			
Sine Wave Pulse Spectral Density relative to PRF ¹	60 dBμV 100 kHz, 1 MHz, 10 MHz, 100 MHz		Direct measurement Note 2: Pulse level for CISPR weighting quasi-peak
	Pulse Level ² : 60 dBμV PRF ¹ : (10 to 200) Hz Band A relative to 25 Hz B, C, D relative to 100 Hz	0.16 dB	
	Pulse Level ² : 40 dBμV PRF ¹ : 0.1 Hz to 20 kHz Band A relative to 25 Hz B,C,D relative to 100 Hz	0.11 dB	
		0.11dB	



Matrix A	Passive Devices Scattering Parameter: Reflection coefficient (linear)	
Frequency	Reflection Coefficient (0 to 1)	
	Uncertainty = $ax^2 + bx + c$	
	Where x is voltage reflection coefficient in linear	
45 MHz to 2.999 GHz	$0.0029x^2 + 0.0033x + 0.0029$	Using E8364B/C 85054B
3 GHz to 8.999 GHz	$0.0059x^2 + 0.0050x + 0.0053$	
9 GHz to 18 GHz	$0.0132x^2 + 0.0061x + 0.0056$	
45 MHz to 2.999 GHz	$0.0053x^2 + 0.0029x + 0.0026$	Using E8364B/C 85052B
3 GHz to 20.999 GHz	$0.0119x^2 + 0.0045x + 0.0042$	
21 GHz to 26.5 GHz	$0.0138x^2 + 0.0077x + 0.0046$	
45 MHz to 20.999 GHz	$0.0044x^2 + 0.0029x + 0.0052$	Using E8364B/C 85056A
21 GHz to 40.999 GHz	$0.0098x^2 + 0.0083x + 0.0084$	
41 GHz to 50 GHz	$0.0109x^2 + 0.0121x + 0.0106$	

Matrix B	Passive Devices Scattering Parameter: Transmission coefficient								
Specific Values	Transmission Coefficient (dB)								
	0 to 10	10 to 20	20 to 30	30 to 40	40 to 50	50 to 60	60 to 70	70 to 80	
45 MHz to 2 GHz	0.022	0.029	0.036	0.046	0.058	0.076	0.102	0.179	Using E8364B/C 85054B
2 GHz to 8 GHz	0.022	0.036	0.044	0.051	0.059	0.076	0.102	0.165	
8 GHz to 18 GHz	0.042	0.055	0.063	0.070	0.078	0.094	0.116	0.165	
45 MHz to 2 GHz	0.020	0.027	0.035	0.045	0.056	0.074	0.100	0.177	Using E8364B/C8 5052B
2 GHz to 8 GHz	0.020	0.034	0.042	0.049	0.057	0.074	0.100	0.169	
8 GHz to 18 GHz	0.047	0.060	0.068	0.075	0.083	0.099	0.120	0.169	
18 GHz to 26.5 GHz	0.074	0.087	0.095	0.102	0.110	0.126	0.145	0.180	Using E8364B/C 85056A
45 MHz to 2 GHz	0.022	0.029	0.036	0.046	0.058	0.076	0.102	0.178	
2 GHz to 18 GHz	0.022	0.036	0.043	0.051	0.059	0.076	0.102	0.156	
18 GHz to 26.5 GHz	0.048	0.061	0.069	0.076	0.085	0.100	0.120	0.156	
26.5 GHz to 50 GHz	0.086	0.110	0.119	0.126	0.135	0.151	0.173	0.228	



Matrix C	Signal Sources -Absolute RF Power in 50 Ω Coaxial Line			Power Sensor/ Spectrum Analyzer
Frequency	RF Power Level (Uncertainty in mW/W unless stated otherwise)			
9 kHz to 6 GHz	10 nW to 100 nW	100 nW to 100 mW		E9304A
	34 to 99	23 to 35		
9 kHz to 18 GHz	10 nW to 100 nW	100 nW to 1 W		E9304A H19
	0.98 nW to 3.7 nW	24 to 37		
10 MHz to 18 GHz	10 nW to 1 mW	1 mW to 1 W		E9300A H25
	37 to 48	32 to 42		
50 MHz to 35 GHz	1 μW to 10 μW	10 μW to 10 mW	10 mW to 100 mW	8487A
	0.13 μW to 0.26 μW	9 to 26	32 to 39	
35 GHz to 45 GHz	0.14 μW to 0.40 μW	14 to 40	35 to 50	
45 GHz to 50 GHz	0.14 μW to 0.61 μW	31 to 61	45 to 69	
9 kHz to 20 GHz	1 fW to 10 fW	10 fW to 3.2 μW		E9304A, 8487A, E4448A
	8 to 20	11 to 22		
20 GHz to 50 GHz	19 to 64	14 to 64		
50 MHz to 20 GHz	500 pW to 10 nW	10 nW to 10 μW		8487D
	0.056 nW to 0.26 nW	14 to 34		
20 GHz to 50 GHz	0.062 nW to 1.1 nW	57 to 120		
10 MHz to 20 GHz	10 μW to 100 mW			N8488A
	10 to 22			
	35 to 53			
	70 to 74			
40 GHz to 50 GHz	97 to 130			
50 GHz to 67 GHz	10 μW to 100 mW			V8486A
	28 to 76			



Matrix D	Signal Sources - RF Power Flatness in 50 Ω Coaxial Line		
Frequency	RF Power Level (Uncertainty in mW/W unless stated otherwise)		Power Sensor
9 kHz to 6 GHz	10 nW to 2.2 mW	2.2 mW to 100 mW	E9304A
	0.58 nW to 1.4 nW	5 to 12	
9 kHz to 18 GHz	10 nW to 100 nW	100 nW to 1 W	E9304A H19
	0.59 nW to 1.3 nW	10 to 13	
10 MHz to 18 GHz	10 nW to 1 mW	1 mW to 1 W	E9300A H25
	9 to 18	9 to 17	
50 MHz to 35 GHz	1 μW to 10 μW	10 μW to 100 mW	8487A
	0.059 nW to 0.22 μW	5 to 22	
35 GHz to 45 GHz	0.064 μW to 0.38 μW	18 to 38	8487A
45 GHz to 50 GHz	0.07 μW to 0.59 μW	31 to 60	
50 MHz to 20 GHz	500 pW to 10 nW	10 nW to 10 μW	8487D
	12 to 58	11 to 24	
20 GHz to 50 GHz	56 to 120	56 to 110	8487D
10 MHz to 20 GHz	10 μW to 100 mW		
		7 to 51	
20 GHz to 40 GHz	34 to 51		N8488A
40 GHz to 50 GHz	69 to 72		
50 GHz to 67 GHz	96 to 130		
50 GHz to 67 GHz	10 μW to 100 mW		V8486A
	13 to 37		



Matrix E				
Signal Analyzers – Absolute RF Power in 50 Ω Coaxial Line				
Frequency	RF Power Level (Uncertainty in mW/W unless stated otherwise)			Power Sensor
10 MHz to 18 GHz	1 nW to 10 nW	10 nW to 1 μW	1 μW to 10 μW	8481D
	0.14 nW to 0.17 nW	15 to 19	20 to 23	
50 MHz to 26.5 GHz	0.14 nW to 0.22 nW	18 to 27	39 to 44	8485D
50 MHz to 30 GHz	0.14 nW to 0.20 nW	15 to 37	38 to 51	8487D
30 GHz to 50 GHz	0.44 nW to 0.21 nW	42 to 160	54 to 170	
75 Ω Type N 100 kHz to 3 GHz	1 μW to 100 μW	100 μW to 3 mW	3 mW to 6.31 mW	8483A
	0.33 μW to 1.4 μW	14 to 30	14 to 30	
100 kHz to 4.2 GHz	0.34 μW to 0.97 μW	10 to 20	32 to 37	8482A
10 MHz to 18 GHz	0.33 μW to 1 μW	10 to 17	32 to 37	8481A
50 MHz to 26.5 GHz	0.34 μW to 1.7 μW	17 to 26	35 to 42	8485A
50 MHz to 45 GHz	0.34 μW to 1.6 μW	16 to 51	16 to 47	8487A
45 GHz to 50 GHz	0.36 μW to 4.5 μW	44 to 120	45 to 110	
10 MHz to 67 GHz	10 μW to 2 mW			N8488A
	32 to 110			

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Sources, DC Voltmeters	150 μV to 10 V	5 nV/V + 100 nV	Josephson Voltage Standard Differential measurement
DC Resistance Sources, Specific Values	0.1 Ω 0.48 Ω 1 Ω 4.8 Ω 10 Ω 65 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ 1 MΩ 10 MΩ 100 MΩ	0.13 μΩ 0.61 μΩ 1.3 μΩ 6.7 μΩ 13 μΩ 87 μΩ 0.13 mΩ 1.3 mΩ 13 mΩ 0.13 Ω 1.6 Ω 21 Ω 0.23 kΩ	Resistance standards and bridge Ratio measurement



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage Sources, Voltage Range	(0 to 0.1) V (0.1 to 1) V (1 to 10) V (10 to 100) V 100 V to 1 kV	0.24 μ V 0.74 μ V 8.5 μ V 74 μ V 1.1 mV	Fluke 732B Voltage Standard, voltmeter, voltage divider Differential measurement
DC Current Sources, Current Range	(0 to 100) μ A (100 to 300) μ A 300 μ A to 1 mA (1 to 3) mA (3 to 10) mA (10 to 30) mA (30 to 100) mA (100 to 300) mA 300 mA to 1 A (1 to 15) A (15 to 100) A (100 to 200) A (200 to 220) A	380 pA 810 pA 3.4 nA 7.3 nA 37 nA 85 nA 0.62 μ A 0.97 μ A 5.9 μ A 82 μ A/A + 3 μ A 76 μ A/A + 66 μ A 150 μ A/A + 570 μ A 21 μ A/A + 64 μ A	Resistance standards and voltmeter Indirect measurement
AC Voltage Sources, Voltage Range	1 mV to 1 kV (See Matrix F)	(See Matrix F)	Fluke 5790A Multi Product Calibrator Direct measurement
AC Current Sources, Current Range	10 μ A to 1 A (See Matrix G)	(See Matrix G)	Fluke 5790A Multi Product Calibrator with ac current shunts Indirect measurement
DC Voltage Meters, Voltage Range	(0 to 0.1) V (0.1 to 1) V (1 to 10) V (10 to 100) V 100 V to 1 kV	95 nV 0.77 μ V 2.2 μ V 0.11 mV 5 mV	Generate using Fluke 5720A Multi Product Calibrator with Multimeter 3458A Direct and Indirect measurement
Resistance Meters, Fixed Value	1 Ω 10 Ω 100 Ω 1 k Ω 10 k Ω 100 k Ω 1 M Ω 10 M Ω 100 M Ω 1 G Ω	4.7 μ Ω 15 μ Ω 0.13 m Ω 1.5 m Ω 5.2 m Ω 0.18 Ω 2.2 Ω 78 Ω 7.9 k Ω 0.21 M Ω	Generate using Fluke 5720A Multi Product Calibrator with Multimeter 3458A Direct measurement

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current Meters, Current Range	(0 to 100) nA 100 nA to 1 μ A (1 to 10) μ A (10 to 100) μ A 100 μ A to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A	4.3 pA 4.3 pA 41 pA 0.48 nA 3.1 nA 26 nA 0.35 μ A 43 μ A	Generate using Fluke 5720A Multi Product Calibrator with Multimeter 3458A Indirect measurement
AC Voltage Meters, Voltage Range	10 mV to 1 kV (See Matrix H)	(See Matrix H)	Generate using Fluke 5720A Multi Product Calibrator, function generator 3325B with Multimeter 3458A Direct and differential measurement
AC Current Meters Current Range	Up to 10 μ A 45 Hz to 1 kHz (10 to 100) μ A 45 Hz to 1 kHz 100 μ A to 1 mA 45 Hz to 1 kHz (1 to 10) mA 45 Hz to 1 kHz (10 to 100) mA 45 Hz to 1 kHz 100 mA to 1 A 45 Hz to 1 kHz	4.2 nA 11 nA 0.11 μ A 1.1 μ A 11 μ A 190 μ A	Generate using Fluke 5720A Multi Product Calibrator with Multimeter 3458A Direct Measurement
4T Capacitance meter	1 pF (20 to 100) Hz 100 Hz to 1 kHz 1 kHz 1 kHz to 1 MHz 1 MHz (1 to 2) MHz 2 MHz	15 fF 0.84 fF 0.12 fF 0.56 fF 0.14 fF 0.58 fF 0.25 fF	Measure using 16380A /16380C Capacitor Set



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
4T Capacitance meter	10 pF		Measure using 16380A /16380C Capacitor Set
	(20 to 100) Hz	19 fF	
	100 Hz to 1 kHz	1.1 fF	
	1 kHz	0.91 fF	
	1 kHz to 1 MHz	0.91 fF	
	1 MHz	0.91 fF	
	(1 to 2) MHz	0.93 fF	
	2 MHz	0.93 fF	
	100 pF		
	(20 to 100) Hz	19 fF	
	100 Hz to 1 kHz	10 fF	
	1 kHz	10 fF	
	1 kHz to 1 MHz	12 fF	
	1 MHz	12 fF	
	(1 to 2) MHz	12 fF	
	2 MHz	12 Ff	
	1 000 pF		
	(20 to 100) Hz	0.64 pF	
	100 Hz to 1 kHz	0.64 pF	
	1 kHz	0.11 pF	
	1 kHz to 1 MHz	0.64 pF	
	1 MHz	0.12 pF	
	(1 to 2) MHz	0.65 pF	
	2 MHz	0.18 pF	
	10 nF		
	(20 to 120) Hz	0.63 pF	
	120 Hz	0.63 pF	
	1 kHz	3.20 pF	
10 kHz	0.53 pF		
100 kHz	35 pF		
100 nF			
(20 to 120) Hz	4.4 pF		
120 Hz	4.4 pF		
1 kHz	4.4 pF		
10 kHz	4.8 pF		
100 kHz	5.1 pF		



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
4T Capacitance meter	1 μ F		Measure using 16380A /16380C Capacitor Set
	(20 to 120) Hz	2.4 nF	
	120 Hz	55 pF	
	1 kHz	47 pF	
	10 kHz	47 pF	
	100 kHz	89 pF	
	10 μ F		
	(20 to 120) Hz	4.1 nF	
	120 Hz	0.77 nF	
	1 kHz	0.78 nF	
	10 kHz	1.8 nF	
	100 kHz	8.4 nF	
4T Dissipation meter	1 pF		Measure using 16380A /16380C Capacitor Set
	(20 to 100) Hz	9.5E-03	
	100 Hz to 1 kHz	9.2E-04	
	1 kHz	2.1E-05	
	1 kHz to 1 MHz	3.1E-05	
	1 MHz	3.1E-05	
	(1 to 2) MHz	6.1E-05	
	2 MHz	6.1E-05	
	10 pF		
	(20 to 100) Hz	1.3E-03	
	100 Hz to 1 kHz	8.7E-05	
	1 kHz	2.1E-05	
	1 kHz to 1 MHz	2.1E-05	
	1 MHz	2.1E-05	
	(1 to 2) MHz	2.1E-05	
	2 MHz	2.1E-05	
	100 pF		
	(20 to 100) Hz	1.6E-04	
	100 Hz to 1 kHz	2.1E-05	
	1 kHz	2.1E-05	
	1 kHz to 1 MHz	2.1E-05	
	1 MHz	2.1E-05	
	(1 to 2) MHz	2.1E-05	
	2 MHz	2.1E-05	



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
4T Dissipation meter	1 000 pF		Measure using 16380A /16380C Capacitor Set
	(20 to 100) Hz	1.9E-04	
	100 Hz to 1 kHz	2.1E-05	
	1 kHz	2.1E-05	
	1 kHz to 1 MHz	3.1E-05	
	1 MHz	3.1E-05	
	(1 to 2) MHz	6.1E-05	
	2 MHz	6.1E-05	
	10 nF		
	(20 to 120) Hz	2.1E-05	
	120 Hz	2.1E-05	
	1 kHz	2.6E-05	
	10 kHz	2.1E-05	
	100 kHz	2.2E-05	
	100 nF		
	(20 to 120) Hz	3.4E-05	
	120 Hz	3.4E-05	
	1 kHz	2.1E-05	
	10 kHz	4.8E-05	
	100 kHz	4.6E-05	
	1 μF		
	(20 to 120) Hz	4.3E-05	
	120 Hz	4.3E-05	
	1 kHz	2.1E-05	
10 kHz	3.1E-05		
100 kHz	3.7E-04		
10 μF			
(20 to 120) Hz	4.6E-05		
120 Hz	4.6E-05		
1 kHz	3.1E-05		
10 kHz	2.9E-04		
100 kHz	7.4E-04		
4T AC Resistance meter	10 Ω		Measure using 42030A Resistor Set
	(20 to 100) Hz	4.3 mΩ	
	100 Hz to 1 MHz	4.5 mΩ	
	1 MHz	3.3 mΩ	
	(1 to 2) MHz	6.0 mΩ	
	2 MHz	5.2 mΩ	



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
4T AC Resistance meter	100 Ω		Measure using 42030A Resistor Set
	(20 to 100) Hz	51 m Ω	
	100 Hz to 1 MHz	51 m Ω	
	1 MHz	31 m Ω	
	(1 to 2) MHz	57 m Ω	
	2 MHz	41 m Ω	
	1 k Ω		
	(20 to 100) Hz	0.39 Ω	
	100 Hz to 1 MHz	0.39 Ω	
	100 kHz	0.31 Ω	
	1 MHz	0.31 Ω	
	(1 to 2) MHz	0.39 Ω	
	2 MHz	0.31 Ω	
	10 k Ω		
	(20 to 100) Hz	2.3 Ω	
	100 kHz to 1 MHz	3.2 Ω	
	100 kHz	2.1 Ω	
	1 MHz	3.1 Ω	
	100 k Ω		
	(20 to 100) Hz	26 Ω	
100 kHz to 1 MHz	25 Ω		
100 kHz	28 Ω		
1 MHz	6.6 Ω		



Matrix F	AC Voltage Sources							
	Frequency Range (kHz)							
	0.01 to 0.02	0.02 to 0.04	0.04 to 20	20 to 50	50 to 100	100 to 300	300 to 500	500 to 1000
	Uncertainty = $u_1 \times \mu\text{V/V} + u_2 \mu\text{V} \times \text{is voltage in V}$							
600 μV to 2 mV	-	-	68x + 1.0	200x + 1.5	190x + 1.9	1100x + 2.7	1600x + 5.7	3900x + 5.4
(2 to 6) mV	73x + 1.0	27x + 1.4	35x + 1.0	75x + 1.4	98x + 1.9	210x + 2.9	620x + 5.8	2200x + 5.5
(6 to 20) mV	64x + 1.1	40x + 0.97	37x + 0.97	140x + 1.1	140x + 1.6	260x + 2.4	500x + 5.4	1400x + 5.6
(20 to 60) mV	64x + 1.1	36x + 1.1	36x + 0.99	77x + 1.1	82x + 1.5	160x + 2.5	350x + 5.1	930x + 5.3
(60 to 200) mV	61x + 0.98	34x + 0.93	29x + 0.92	29x + 1.3	82x + 1.2	150x + 2.3	320x + 4.9	840x + 5.6
(200 to 600) mV	-	-	24x + 1.3	-	-	-	-	-
600 mV to 2 V	50x + 0.38	26x + 0.34	19x + 0.22	21x + 0.14	40x + 0.19	88x + 0.77	180x + 3.0	690x + 2.9
(2 to 6) V	-	-	22x + 2.5	-	40x + 0.19	-	-	-
(6 to 20) V	49x + 10	27x + 11	17x + 33	21x + 33	48x + 79	120x + 3.7	300x + 14	930x + 0.69
(20 to 60) V	50x + 26	27x + 110	21x + 17	23x + 22	53x + 61	-	-	-
(60 to 200) V	50x + 73	27x + 260	22x + 310	27x + 700	53x + 840	-	-	-
(200 to 400) V	-	-	18x + 3800	85x + 1200	-	-	-	-
(400 to 600) V	-	-	-	88x + 71	390x + 540	-	-	-
(600 to 700) V	-	-	25x + 550	89x + 330	-	-	-	-
(700 to 1 000) V	-	34x + 370	30x + 440	-	-	-	-	-

Matrix G	AC Current Sources				
	Frequency (kHz)				
Current Range	0.01 to 0.02	0.02 to 0.045	0.045 to 0.1	0.1 to 5	5 to 10
(0 to 10) μA	2.3 nA	2.3 nA	2.1 nA	2.3 nA	2.3 nA
(10 to 100) μA	18 nA	17 nA	17 nA	16 nA	18 nA
100 μA to 1 mA	150 nA	150 nA	140 nA	140 nA	150 nA
(1 to 10) mA	1.4 μA	1.4 μA	1.3 μA	1.3 μA	1.4 μA
(10 to 100) mA	14 μA	14 μA	13 μA	13 μA	14 μA
100 mA to 1 A	180 μA	170 μA	170 μA	160 μA	180 μA



Matrix H	AC Voltage Meters					
	Frequency (kHz)					
Voltage Range	0.001 to 0.04	0.04 to 1	1 to 20	20 to 50	50 to 100	100 to 300
(0 to 10) mV	-	-	350 nV	350 nV	-	540 nV
(10 to 100) mV	-	-	3 μV	3 μV	-	5 μV
100 mV to 1 V	-	15 μV	13 μV	16 μV	26 μV	51 μV
(1 to 10) V	140 μV	140 μV	100 μV	260 μV	1.4 mV	560 μV
(10 to 100) V	-	2.4 mV	2.1 mV	2.0 mV	1.9 mV	-
(100 to 750) V	-	13 mV	81 mV	-	-	-
Voltage Range	Frequency (MHz)					
	0.3 to 1	1 to 2	2 to 4	4 to 8	8 to 10	
(0 to 10) mV	1.1 μV	4.7 μV	52.0 μV	-	-	
(10 to 100) mV	11 μV	58 μV	520 μV	990 μV	1.2 mV	
100 mV to 1 V	74 μV	-	5.2 mV	9.9 mV	6.2 mV	
(1 to 3) V	-	15 mV	16 mV	30 mV	37 mV	
(1 to 10) V	2.3 mV	-	-	-	-	

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Meters, Specific Values	1 Hz 10 MHz	20 μHz 58 Hz	Generate using function generator 3325B Direct measurement
Time Interval Measure	(0.8 to 20) nS 20 ns to 10 μS 10 μs to 1 mS 1 mS to 1 S (1 to 10) S	1 mS/S + 9 pS 30 pS/S + 1 nS 20 pS/s + 1 nS 10 pS/S + 1 nS 5 pS/S + 1 nS	Measuring using scope 86100C and Frequency Counter 53132A Direct measurement
Frequency Sources	10 MHz	1.3×10^{-11} Hz/Hz	Measure using 5071A Frequency Standard, 53132A Counter Differential measurement

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Signal Sources –Frequency	100 MHz to 45 GHz	1.5×10^{-11} Hz/Hz	Signal Analyzer E4448A Frequency Standard 5071A Frequency Standard Differential measurement

Calibration and Measurement Capability (CMC) is expressed in terms of the measurement parameter, measurement range, expanded uncertainty of measurement and reference standard, method, and/or equipment. The expanded uncertainty of measurement is expressed as the standard uncertainty of the measurement multiplied by a coverage factor of 2 (k=2), corresponding to a confidence level of approximately 95%.

Notes:

1. On-site calibration service is available for this parameter, since on-site conditions are typically more variable than those in the laboratory, larger measurement uncertainties are expected on-site than what is reported on the accredited scope.
2. % = percent of reading unless indicated otherwise.
3. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-1928.



Vice President