



CERTIFICATE OF ACCREDITATION

ANSI National Accreditation Board
11617 Coldwater Road, Fort Wayne, IN 46845 USA

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 17025:2017

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 activities to which this accreditation applies

AC-1928

Certificate Number


ANAB Approval

Certificate Valid Through: 03/11/2022
Version No. 010 Issued: 03/10/2020



This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. 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 17025:2017,
ANSI/NCSL Z540-1-1994 (R2002) AND ANSI/NCSL Z540.3-2006 (R2013)**

Keysight Technologies (Malaysia) SDN BHD

Phase 3, Bayan Lepas Free Industrial Zone

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CALIBRATION

Valid to: **March 11, 2022**

Certificate Number: **AC-1928**

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Power Sources ¹ Fitted with female Type-N connectors	1 mW at 50 MHz	2.2 μW	Thermistor Mount 478A Direct measurement (1 mW 50 MHz Reference Source Calibration)
Passive Devices Scalar Attenuation, Measure ¹	1.01 kHz to 1 MHz (0 to 40) dB (40 to 80) dB (80 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 to 40) dB (40 to 80) dB (80 to 110) dB	0.005 dB 0.01 dB 0.03 dB	
	80 MHz to 6 GHz (0 to 40) dB (40 to 80) dB (80 to 110) dB	0.01 dB 0.021 dB 0.032 dB	
Passive Devices Scattering Parameter: Reflection coefficient (linear) ^{1,3}	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	



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Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Passive Devices Scattering Parameter: Reflection coefficient (linear) ¹	45 MHz to 50 GHz	(See Matrix A)	Measure using E8364B/C Network Analyzer Direct Measurement
Passive Devices Scattering Parameter: Transmission coefficient ¹	10 kHz to 30 kHz (0 to 10) dB (10 to 20) dB (20 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 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 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)	
Power Sensor, Calibration Factors ¹	100 pW to 1 μW (10 to 50) MHz 50 MHz to 18 GHz (18 to 26.5) GHz (26.5 to 50) GHz (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 100 μW to 10 mW (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	0.35 % Cal Factor 0.35 % Cal Factor 1.3 % Cal Factor 1.3 % Cal Factor 0.4 % Cal Factor 0.3 % Cal Factor 0.3 % Cal Factor 0.3 % Cal Factor 0.32 % Cal Factor 1 % Cal Factor 1.3 % Cal Factor 0.4 % Cal Factor 0.3 % Cal Factor 0.3 % Cal Factor 0.3 % Cal Factor 0.32 % Cal Factor 1 % Cal Factor 1.3 % Cal Factor	Reference to 1 mW at 50 MHz Substitution measurement



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Power Sensor, Calibration Factors ¹	(10 to 100) mW (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 100 mW to 3 W 100 kHz to 10 MHz 10 MHz to 4.2 GHz (4.2 to 18) GHz	0.4 % Cal Factor 0.3 % Cal Factor 0.3 % Cal Factor 0.3 % Cal Factor 0.32 % Cal Factor 1 % Cal Factor 1.3 % Cal Factor 0.3 % Cal Factor 0.3 % Cal Factor 0.33 % Cal Factor	Reference to 1 mW at 50 MHz Substitution measurement
Power Sensor, Calibration Factors 75 Ω System ¹	1 μW to 100 mW 100 kHz to 2 GHz	0.97 % Cal Factor	Reference to 1 mW at 50 MHz Substitution measurement
Scattering Parameter ¹ : Reflection Coefficient, Γ Passive Devices fitted with Type-N connectors Passive Devices fitted 3.5 mm connectors	$-1 \leq \text{Re}\{\Gamma\} \leq 1$ $-1 \leq \text{Im}\{\Gamma\} \leq 1$ constrained by: $0 \leq \Gamma \leq 1$ 45 MHz to 18 GHz 45 MHz to 33 GHz	 0.003 Γ 0.004 Γ	Measure using iPIMMS Substitution measurement
Scattering Parameter: Transmission Coefficient ^{1,2} 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 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (90 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

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scattering Parameter: Transmission Coefficient ^{1,2} 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 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (90 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 ¹	(See Matrix C)	(See Matrix C)	Direct measurement Power Sensor, Power Meter
Signal Sources – RF Power Flatness in Coaxial Line ¹	(See Matrix D)	(See Matrix D)	Direct measurement Power Sensor, Power Meter
Signal Sources -Harmonic Content ¹	Fundamental Frequency 1 MHz to 25 GHz (0 to 10) dBm Harmonic Frequency 2 MHz to 50 GHz (-110 to 0) dBm	0.51 dB	Signal analyzer E4448A Direct measurement
Signal Sources - Pulse Time Parameters Rise/Fall Time ¹	(0 to 10) dBm 10 MHz to 50 GHz 18 ps to 10 ns	86 ps	Oscilloscope mainframe 86100C, Electrical module 86117A Direct measurement
Signal Sources - Modulation ¹ 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 $\beta > 0.2$ f_c : 250 kHz to 10 MHz f_m : 20 Hz to 10 kHz Δf : 200 Hz to 40 kHz $\beta > 1.2$	0.015 Hz/Hz 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



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Signal Sources - Modulation ¹ Frequency Modulation Peak Frequency Deviation	f_c : 10 MHz to 6.6 GHz f_m : 50 Hz to 200 kHz Δf : 250 Hz to 400 kHz $\beta > 0.2$	0.015 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 : 10 MHz to 6.6 GHz f_m : 50 Hz to 200 kHz Δf : 250 Hz to 400 kHz $\beta > 0.45$	0.01 Hz/Hz	
	f_c : 6.6 GHz to 13.2 GHz f_m : 50 Hz to 200 kHz Δf : 250 Hz to 400 kHz $\beta > 0.2$	0.025 Hz/Hz	
	(-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	
	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	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Signal Sources ¹ 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) % f_c : (3 to 26.5) GHz Depth: (5 to 20) % f_c : (26.5 to 31.15) GHz Depth: (20 to 99) % f_c : (26.5 to 31.15) GHz Depth: (5 to 20) % f_c : (31.15 to 50) GHz Depth: (5 to 20) % f_c : (31.15 to 50) GHz Depth: (5 to 20) %	0.0075 % Depth 0.005 % Depth 0.025 % Depth 0.015 % Depth 0.045 % Depth 0.019 % Depth 0.068 % Depth 0.06 % Depth 0.26 % Depth	Signal analyzer E4448A f_c = Carrier Frequency f_m = Modulation Rate Direct measurement
Phase Modulation ¹ Peak phase deviation	(-18 to 30) dBm f_c : 100 kHz to 6.6 GHz $\Delta\Phi > 0.7$ rad f_c : 100 kHz to 6.6 GHz $\Delta\Phi > 0.3$ rad f_c : (6.6 to 13.2) GHz $\Delta\Phi > 2.0$ rad	0.01 rad/rad 0.03 rad/rad 0.01 rad/rad	Signal analyzer E4448A f_c = Carrier Frequency $\Delta\Phi$ = Phase Deviation Direct measurement



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Modulation ¹ Peak phase deviation	(-18 to 30) dBm f_c : (6.6 to 13.2) GHz $\Delta\Phi > 0.6$ rad	0.03 rad/rad	Signal analyzer E4448A f_c = Carrier Frequency $\Delta\Phi$ = Phase Deviation Direct measurement
	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	
	f_c : (26.5 to 31.15) GHz $\Delta\Phi > 1.3$ rad	0.03 rad/rad	
	f_c : (31.15 to 50) GHz $\Delta\Phi > 8$ rad	0.01 rad/rad	
	f_c : (31.15 to 50) GHz $\Delta\Phi > 2.4$ rad	0.03 rad/rad	
Phase Modulation ¹ Modulation Rate	(-18 to 30) dBm $100 \text{ kHz} \leq f_c < 50 \text{ GHz}$		Signal analyzer E4448A $\beta = \Delta f / f_m$ f_m = Modulation Rate Direct measurement
Amplitude Modulation Rate	Depth $\geq 20\%$ $f_m \leq 100 \text{ kHz}$	0.062 Hz	
Frequency Modulation Rate	$\beta \geq 0.01$ $f_m \leq 200 \text{ kHz}$	0.062 Hz	
Phase Modulation Rate	$\beta \geq 0.01$ $f_m \leq 20 \text{ kHz}$	0.062 Hz	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<p>Signal Sources - Modulation Distortion¹</p> <p>Amplitude Modulation Distortion</p>	<p>(0.01 to 100) % Distortion f_m: 20 Hz to 1 kHz f_c: 100 kHz to 10 MHz Depth: > 1 % Depth: > 3 %</p> <p>f_m: 20 Hz to 1 kHz f_c: 10 MHz to 26.5 GHz Depth: > 1 % Depth: > 3 %</p> <p>f_m: 20 Hz to 1 kHz f_c: (26.5 to 50) GHz Depth: > 1 % Depth: > 3 % Depth: > 5 %</p>	<p>0.001 2 %/% + 0.8 % Depth 0.001 2 %/% + 0.3 % Depth</p> <p>0.001 2 %/% + 1 % Depth 0.001 2 %/% + 0.4 % Depth</p> <p>0.001 2 %/% + 6.2 % Depth 0.001 2 %/% + 2 % Depth 0.001 2 %/% + 1.5 % Depth</p>	<p>Signal analyzer E4448A f_c =Carrier Frequency f_m = Modulation Rate Direct measurement</p>
<p>Signal Sources^{1,2}</p> <p>Phase Modulation Distortion</p>	<p>(0.01 to 100) % Distortion f_c: 1 MHz to 6.6 GHz f_m: (20 to 500) Hz $\Delta\Phi > 0.8$ rad $\Delta\Phi \geq 2.5$ rad</p> <p>f_c: 1 MHz to 6.6 GHz f_m: 500 Hz to 1 kHz $\Delta\Phi > 0.4$ rad $\Delta\Phi \geq 1.0$ rad</p> <p>f_c: (6.6 to 13.2) GHz f_m: (20 to 500) Hz $\Delta\Phi > 1.8$ rad $\Delta\Phi \geq 5.5$ rad</p> <p>f_c: (13.2 to 31.15) GHz f_m: (20 to 500) Hz $\Delta\Phi > 3.5$ rad $\Delta\Phi \geq 10.0$ rad</p> <p>f_c: (13.2 to 31.15) GHz f_m: 500 Hz to 1 kHz $\Delta\Phi > 1.2$ rad $\Delta\Phi \geq 4.0$ rad</p>	<p>0.001 2 %/% + 0.3 %D 0.001 2 %/% + 0.1 %D</p> <p>0.001 2 %/% + 0.3 %D 0.001 2 %/% + 0.1 %D</p> <p>0.001 2 %/% + 0.3 %D 0.001 2 %/% + 0.1 %D</p> <p>0.001 2 %/% + 0.3 %D 0.001 2 %/% + 0.1 %D</p> <p>0.001 2 %/% + 0.3 %D 0.001 2 %/% + 0.1 %D</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 ^{1,2} Phase Modulation Distortion	(0.01 to 100) % Distortion f _c : (31.15 to 50) GHz f _m : (20 to 500) Hz ΔΦ > 7.5 rad ΔΦ ≥ 19.0 rad 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 %D 0.001 2 %/% + 0.1 %D 0.001 2 %/% + 0.3 %D 0.001 2 %/% + 0.1 %D	Signal analyzer E4448A f _c =Carrier Frequency f _m = Modulation Rate Direct measurement
Signal Sources ^{1,2} Frequency Modulation Distortion	(0.01 to 100) % Distortion f _c : (6.6 to 13.2) GHz f _m : 20 Hz to 1 kHz Δf > 2.3 kHz Δf ≥ 4.5 kHz f _c : (13.2 to 31.15) GHz f _m : 20 Hz to 1 kHz Δf > 2.7 kHz Δf ≥ 6.0 kHz f _c : (31.15 to 50) GHz f _m : 20 Hz to 1 kHz Δf > 4.0 kHz Δf ≥ 12.0 kHz 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 %D 0.001 2 %/% + 0.1 %D 0.001 2 %/% + 0.3 %D 0.001 2 %/% + 0.1 %D 0.001 2 %/% + 0.3 %D 0.001 2 %/% + 0.1 %D 0.001 2 %/% + 0.3 %D 0.001 2 %/% + 0.1 %D	Signal analyzer E4448A f _c =Carrier Frequency f _m = Modulation Rate Direct measurement

DIGITAL MODULATION RF QUALITY

PARAMETER/EQUIPMENT	MODULATION TYPES	FREQUENCY RANGE
Digital Modulation RF Quality ¹ Measure – Carrier 2 MHz to 44 GHz	TETRA, PDC, NADC, PHS, EDGE, CDMA 2000A/C, WCDMA, 3GPP, QPSK, BPSK, PI/4 DQPSK, 16QAM, 256QAM, DECT, PHP, GSM, 2FSK, 4FSK, GMSK, MSK, DQPSK, 8PSK, 32QAM FSK	2 MHz to 2.65 GHz using the VSA directly (2.65 to 44) GHz. The digitally modulated RF signal needs to be down-converted with an external Mixer and a Local Oscillator L.O. center frequency = 150 MHz



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Signal Sources – Digital Modulation ¹ , Carrier: 2 MHz to 2.65 GHz Error Vector Magnitude (EVM)	Mod Frequency Span: $f \leq 100\text{kHz}$ $100\text{kHz} \leq f \leq 1\text{MHz}$ $f > 1\text{MHz}$	0.43 % of reading 0.48 % of reading 0.82 % of reading	<p>HP 89441A Vector Signal Analyzer</p> <p>Modulation Types: TETRA, PDC, NADC, PHS, EDGE, CDMA 2000A/C, WCDMA, 3GPP, QPSK, BPSK, PI/4 DQPSK, 16QAM, 256QAM, DECT, PHP, GSM, 2FSK, 4FSK, GMSK, MSK, DQPSK, 8PSK, 32QAM FSK</p> <p>Frequency Range: 2 MHz to 2.65 GHz using the VSA directly (2.65 to 44) GHz. The digitally modulated RF signal needs to be down converted with an external Mixer and a Local Oscillator L.O. center frequency = (RF-150 MHz)</p>
Signal Sources – Digital Modulation ¹ Carrier: 2 MHz to 2.65 GHz Phase Error	Up to 180 ° Mod Frequency Span: $f \leq 100\text{kHz}$ $100\text{kHz} \leq f \leq 1\text{MHz}$ $f > 1\text{MHz}$	0.17 ° rms 0.34 ° rms 0.57 ° rms	
Signal Sources – Digital Modulation ¹ , Carrier: 2 MHz to 2.65 GHz Frequency Error	Mod Frequency 1 GHz 2 GHz 3 GHz 4 GHz 5 GHz 6 GHz	0.063 % of reading 0.068 % of reading 0.079 % of reading 0.099 % of reading 0.33 % of reading 0.39 % of reading	
Signal Sources – Digital Modulation ¹ , Carrier: 2 MHz to 2.65 GHz Modulation Accuracy (Rho)	Mod Frequency Span: $f \leq 100\text{kHz}$ $0.9999 \leq \rho \leq 1$ $0.9975 \leq \rho < 0.9999$ $0.9936 \leq \rho < 0.9975$ $0.99 \leq \rho < 0.9936$ $0.978 \leq \rho < 0.99$ $0.96 \leq \rho < 0.978$ Mod Frequency Span: $100\text{ kHz} \leq f \leq 1\text{ MHz}$ $0.9999 \leq \rho \leq 1$ $0.9975 \leq \rho < 0.9999$ $0.9936 \leq \rho < 0.9975$ $0.99 \leq \rho < 0.9936$ $0.978 \leq \rho < 0.99$ $0.96 \leq \rho < 0.978$ Mod Frequency Span: $f > 1\text{MHz}$ $0.9999 \leq \rho \leq 1$ $0.9975 \leq \rho < 0.9999$ $0.9936 \leq \rho < 0.9975$ $0.99 \leq \rho < 0.9936$ $0.978 \leq \rho < 0.99$ $0.96 \leq \rho < 0.978$	$8.6\text{E}^{-5} \rho$ 0.000 43 ρ 0.000 68 ρ 0.000 84 ρ 0.001 2 ρ 0.001 6 ρ $9.6\text{E}^{-5} \rho$ 0.000 48 ρ 0.000 76 ρ 0.000 94 ρ 0.001 4 ρ 0.001 8 ρ $1.6\text{E}^{-4} \rho$ 0.000 82 ρ 0.001 3 ρ 0.001 6 ρ 0.002 4 ρ 0.003 ρ	



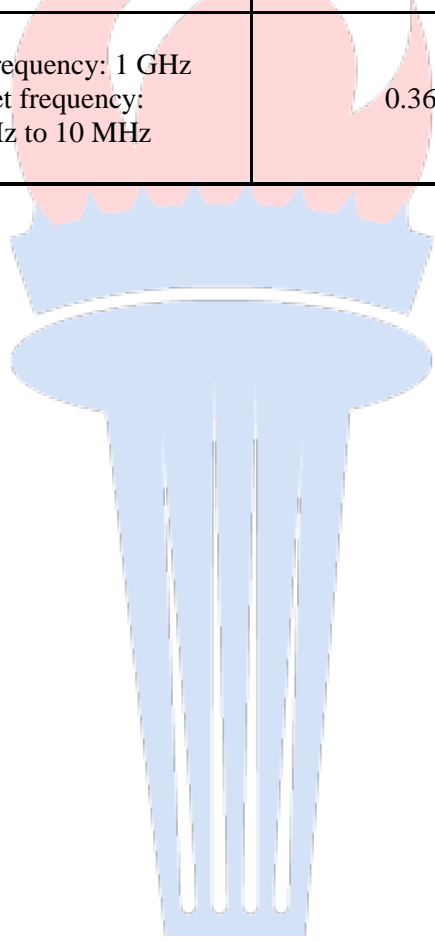
Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
SSB Phase Noise for Signal Sources ¹			
Offset Frequency	(LREF - LDUT) ≥ 10 dBc		
≤ 100 kHz	f ≤ 100 MHz	2.3 dB	
≤ 100 kHz	100 MHz < f ≤ 26.5 GHz	2.3 dB	
≤ 1 MHz	50 kHz < f ≤ 26.5 GHz	2.3 dB	
≤ 10 MHz	50 kHz < f ≤ 26.5 GHz	4.6 dB	
< 100 MHz	50 kHz < f ≤ 26.5 GHz	4.6 dB	
Offset Frequency	10 dBc > (LREF - LDUT) ≥ 5 dBc		
≤ 100 kHz	f ≤ 100 MHz	2.8 dB	
≤ 100 kHz	100 MHz < f ≤ 26.5 MHz	2.9 dB	
≤ 1 MHz	50 kHz < f ≤ 26.5 GHz	2.9 dB	
≤ 10 MHz	50 kHz < f ≤ 26.5 GHz	5.2 dB	
< 100 MHz	50 kHz < f ≤ 26.5 GHz	5.3 dB	
Offset Frequency	5dBc > (LREF - LDUT) ≥ 3 dBc		
≤ 100 kHz	f ≤ 100 MHz	3.2 dB	
≤ 100 kHz	100 MHz < f ≤ 26.5G Hz	3.3 dB	
≤ 1 MHz	50 kHz < f ≤ 26.5 GHz	3.3 dB	
≤ 10 MHz	50 kHz < f ≤ 26.5 GHz	5.4 dB	
< 100 MHz	50 kHz < f ≤ 26.5 GHz	5.5 dB	
Offset Frequency	3 dBc > (LREF - LDUT) ≥ 0 dBc		
≤ 100 kHz	f ≤ 100 MHz	4.3 dB	
≤ 100 kHz	100 MHz < f ≤ 26.5 GHz	4.3 dB	
≤ 1 MHz	50 kHz < f ≤ 26.5 GHz	4.3 dB	
≤ 10 MHz	50 kHz < f ≤ 26.5 GHz	6.1 dB	
< 100 MHz	50 kHz < f ≤ 26.5 GHz	6.2 dB	
SSB Phase Noise for Signal Sources ¹			
Offset Frequency	3 dBc > (LREF - LDUT) ≥ 0 dBc		
≤ 100 kHz	f ≤ 100 MHz	4.3 dB	
≤ 100 kHz	100 MHz < f ≤ 255 MHz	4.3 dB	
≤ 100 kHz	255 MHz < f ≤ 600 MHz	4.3 dB	
≤ 100 kHz	600 MHz < f ≤ 1.8 GHz	4.3 dB	
≤ 100 kHz	1.8 GHz < f ≤ 3.2 GHz	4.3 dB	
≤ 100 kHz	3.2 GHz < f ≤ 10 GHz	4.3 dB	
≤ 100 kHz	10 GHz < f ≤ 20 GHz	4.3 dB	
≤ 100 kHz	20 GHz < f ≤ 26.5 GHz	4.3 dB	
≤ 1 MHz	50 kHz < f ≤ 26.5 GHz	4.3 dB	
≤ 10 MHz	50 kHz < f ≤ 26.5 GHz	6.1 dB	
< 100 MHz	50 kHz < f ≤ 26.5 GHz	6.2 dB	
			Keysight N5500A Phase Noise System
			Keysight N5500A Phase Noise System



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Signal Analyzers – Absolute RF Power in Coaxial Line ¹	(See Matrix E)	(See Matrix E)	Signal Sources, Power Splitters, Power Meters, Power Sensors Direct measurement
Signal Analyzers – Relative RF Power in Coaxial Line ¹	(0 to 70) dB (70 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 ¹	100 MHz to 50 GHz	1.4×10^{-11} Hz/Hz	Signal Source E8257D, Frequency Standard 5071A Differential measurement
Signal Analyzers – Phase Noise ¹	Carrier frequency: 1 GHz Offset frequency: 100 Hz to 10 MHz	0.36 dB	Signal Source 500-13438, Keysight E8257D, Source phase noise: -107 to -167 dBc/Hz, Direct measurement



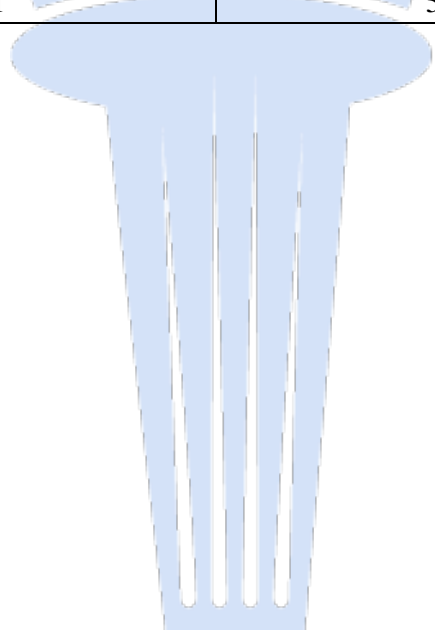
Electrical – RF/Microwave

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 ¹	13.50 μVs	0.27 dB	Direct measurement PRF ¹ = pulse repetitive frequency	
	1.350 μVs	0.26 dB		
	Band A (9 to 150) kHz PRF ¹ : 25 Hz			
	0.3160 μVs	0.26 dB		
	Sine Wave ¹ Pulse Spectral Density relative to PRF ¹	0.0316 μVs	0.26 dB	Pulse Generator IGUU 2916
		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 ¹ Pulse Spectral Density relative to PRF ¹	60 dBμV	0.16 dB	Direct measurement Note 2: Pulse level for CISPR weighting quasi-peak	
	100 kHz, 1 MHz, 10 MHz, 100 MHz			
	Pulse Level ² : 60 dBμV PRF ¹ : (10 to 200) Hz	0.11 dB		
	Band A relative to 25 Hz B, C, D relative to 100 Hz Pulse Level ² : 40 dBμV PRF ¹ : 0.1 Hz to 20 kHz	0.11dB		
Band A relative to 25 Hz B, C, D relative to 100 Hz				

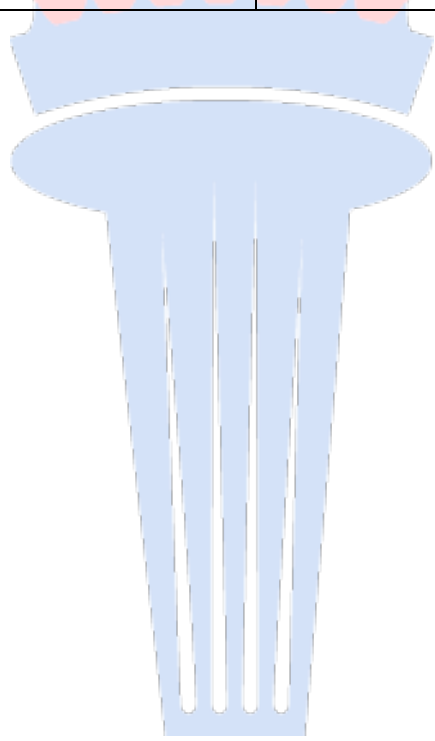
Matrix A	Passive Devices Scattering Parameter: Reflection coefficient (linear)	
	Reflection Coefficient (0 to 1)	
	Uncertainty = $ax^2 + bx + c$ Where x is voltage reflection coefficient in linear	
Frequency		
45 MHz to 2.999 GHz	$0.0029x^2 + 0.0033x + 0.0029$	Using E8364B/C 85054B
3 GHz to 8.999 GHz	$0.0059x^2 + 0.005x + 0.0053$	
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								
	Transmission Coefficient (dB)								
Specific Values	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			
Frequency Range	RF Power Level (Uncertainty in mW/W)			Power Sensor/ Spectrum Analyzer
9 kHz to 6 GHz	10 nW to 1μW	1μW to 100μW	100μW to 100mW	E9304A
	16	16	16	
9 kHz to 18 GHz	10nW to 1mW		1mW to 1W	E9304A H19
	18		18	
10 MHz to 18 GHz	10nW to 1mW		1mW to 1W	E9300A H25
	21		21	
50 MHz to 50 GHz	1μW to 10μW	10 μW to 1mW	1mW to 100mW	8487A
	21	18	18	
9 kHz to 50 GHz	1fW to 10fW		10fW to 3.16μW	E9304A, 8487A, E4448A
	24		25	
50 MHz to 50 GHz	100pW to 32nW	32nW to 1μW	1μW to 10μW	8487D
	22	21	21	
10 MHz to 67 GHz	10μW to 1mW		1mW to 100mW	N8488A
	17		17	
50 GHz to 67 GHz	10μW to 1mW		1mW to 100mW	V8486A
	51		51	



Matrix D	Signal Sources - RF Power Flatness in 50 Ω Coaxial Line			
Frequency Range	RF Power Level (Uncertainty in mW/W)			Power Sensor
9 kHz to 6 GHz	10nW to 1μW	1 μW to 100μW	100 μW to 100mW	E9304A
	5	5	5	
9 kHz to 18 GHz	1nW to 10nW	10nW to 1mW	1mW to 1W	E9304A H19
	28	10	9	
10 MHz to 18 GHz	10 nW to 1 mW		1 mW to 1 W	E9300A H25
	9		9	
50 MHz to 50 GHz	1μW to 10μW	10μW to 1mW	1mW to 100mW	8487A
	5	5	5	
50 MHz to 50 GHz	100 pW to 32nW	32nW to 1μW	1μW to 10μW	8487D
	11	11	11	
10 MHz to 67 GHz	10μW to 1mW		1mW to 100mW	N8488A
	7		7	
50 GHz to 67 GHz	10μW to 1mW		1mW to 100mW	V8486A
	13		13	



Matrix E		Signal Analyzers – Absolute RF Power in 50 Ω Coaxial Line					
Frequency Range	RF Power Level (Uncertainty in mW/W)					Power Sensor	
	10μW to 1nW	1nW to 500nW		500nW to 1μW			
10 MHz to 18 GHz	20	9.8		9.8		8481D	
50 MHz to 26.5 GHz	39	18		18		8485D	
50 MHz to 50 GHz	38	15		15		8487D	
Frequency Range	RF Power Level (Uncertainty in mW/W)					Power Sensor	
	1mW to 1μW	1μW to 100μW	100μW to 500μW	500μW to 700μW	700μW to 3mW		3mW to 6.31mW
100 kHz to 3 GHz	14	14	14	14	14	14	75 Ω Type N 8483A
100 kHz to 4.2 GHz	9.3	9.7	9.2	9.2	9.2	9.2	8482A
10 MHz to 18 GHz	9.4	10	9.4	9.4	9.4	9.2	8481A
50 MHz to 26.5 GHz	17	17	17	17	17	17	8485A
50 MHz to 50 GHz	16	16	16	16	16	16	8487A
Frequency Range	RF Power Level (Uncertainty in mW/W)					Power Sensor	
	10μW to 1mW			1mW to 2mW			
10 MHz to 67 GHz	32			32		N8488A	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage Sources, DC Voltmeters	150 μV to 10 V	5 nV/V + 100 nV	Josephson Voltage Standard Differential measurement
DC Voltage Sources ¹	0 V 100 mV 1 V 10 V 100 V 1 kV	0.15 μV 2.2 μV/V 1.5 μV/V 0.51 μV/V 1.2 μV/V 1.2 μV/V	Fluke 732A DC Reference Standard, Fluke 752A Divider, Keysight 34420A Multimeter
AC Voltage Sources ¹	0.6 mV 1 kHz	0.4 μV	Fluke 5790A Multiproduct Calibrator



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage Sources ¹	2 mV		Fluke 5790A Multiproduct Calibrator
	10 Hz	2.4 μ V	
	20 Hz	1.5 μ V	
	40 Hz to 20 kHz	1.1 μ V	
	50 kHz	1.9 μ V	
	100 kHz	2.5 μ V	
	300 kHz	4.3 μ V	
	500 kHz	5.5 μ V	
	1 MHz	6.7 μ V	
	20 mV		
	10 Hz	3.8 μ V	
	20 Hz	2.7 μ V	
	40 Hz	2 μ V	
	(1 to 20) kHz	1.9 μ V	
	50 kHz	3.3 μ V	
	100 kHz	4.7 μ V	
	300 kHz	11 μ V	
	500 kHz	13 μ V	
	1 MHz	19 μ V	
	200 mV		
	10 Hz	23 μ V	
	20 Hz	10 μ V	
	40 Hz	5.3 μ V	
	1 kHz	5.2 μ V	
20 kHz	5.4 μ V		
50 kHz	9.3 μ V		
100 kHz	20 μ V		
300 kHz	31 μ V		
500 kHz	47 μ V		
1 MHz	0.11 mV		
0.5 V			
40 Hz	9.3 μ V		
1 kHz	9.5 μ V		
20 kHz	9.6 μ V		
100 kHz	24 μ V		
300 kHz	49 μ V		
1 MHz	0.24 mV		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage Sources ¹	1 V		Fluke 5790A Multiproduct Calibrator
	40 Hz	14 μ V	
	1 kHz	14 μ V	
	20 kHz	14 μ V	
	100 kHz	38 μ V	
	300 kHz	86 μ V	
	1 MHz	0.51 mV	
	2V		
	10 Hz	0.21 mV	
	20 Hz	75 μ V	
	40 Hz	28 μ V	
	1 kHz	27 μ V	
	20 kHz	27 μ V	
	50 kHz	57 μ V	
	100 kHz	77 μ V	
	300 kHz	0.17 mV	
	500 kHz	0.29 mV	
	1 MHz	1 mV	
	2.3 V		
	1 kHz	32 μ V	
	20 V		
	10 Hz	2.1 mV	
	20 Hz	0.77 mV	
	40 Hz to 20 kHz	0.31 mV	
	50 kHz	0.51 mV	
	100 kHz	0.86 mV	
	300 kHz	2 mV	
	500 kHz	4.1 mV	
	1 MHz	13 mV	
	200 V		
10 Hz	22 mV		
20 Hz	7.8 mV		
40 Hz	3.7 mV		
1 kHz	3.6 mV		
20 kHz	3.7 mV		
50 kHz	7.3 mV		
100 kHz	11 mV		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage Sources ¹	50 V		Fluke 5790A Multiproduct Calibrator
	300 kHz	5.4 mV	
	30 V		
	500 kHz	13 mV	
	22 V		
	1 MHz	25 mV	
	250 V		
	15 Hz	50 mV	
	300 V		
	40 Hz	7.5 mV	
	1 kHz	7.7 mV	
	20 kHz	7.8 mV	
	50 kHz	21 mV	
	100 kHz	78 mV	
	500 V		
	50 Hz	13 mV	
	1 kHz	13 mV	
	600 V		
	40 Hz	15 mV	
	1 kHz	16 mV	
20 kHz	16 mV		
50 kHz	41 mV		
100 kHz	0.15 V		
1 kV			
40 Hz	38 mV		
50 Hz	38 mV		
300 Hz	24 mV		
1 kHz	24 mV		
20 kHz	25 mV		
30 kHz	72 mV		





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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current Sources ¹	20 μ A		Fluke 5790A Multiproduct Calibrator Fluke A40B Current Shunt
	1 kHz, 10 kHz	2.8 nA	
	200 μ A		
	10 Hz	35 nA	
	20 Hz	15 nA	
	40 Hz	8.6 nA	
	(1 to 5) kHz	8.5 nA	
	10 kHz	8.7 nA	
	2 mA		
	10 Hz	0.35 μ A	
	20 Hz	0.16 μ A	
	40 Hz	90 nA	
	1 kHz	90 nA	
	(5 to 10) kHz	91 nA	
	20 mA		
	10 Hz	3.2 μ A	
	20 Hz	1.2 μ A	
	40 Hz to 10 kHz	0.67 μ A	
	200 mA		
	10 Hz	32 μ A	
	20 Hz	12 μ A	
	40 Hz to 10 kHz	6.7 μ A	
	2 A		
	20 Hz	0.15 mA	
1 kHz	0.11 mA		
5 kHz	0.11 mA		
10 kHz	0.13 mA		
3 A			
40 Hz	0.15 mA		
1 kHz	0.15 mA		
5 kHz	0.15 mA		
10 kHz	0.15 mA		
10 A			
40 Hz	0.25 mA		
1 kHz	0.87 mA		
5 kHz	0.9 mA		
10 kHz	0.9 mA		



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current Sources ¹	0 μ A 10 μ A 200 μ A 2 mA 20 mA 100 mA 200 mA 1 A 2 A 3 A 5 A 10 A	0.76 pA 0.14 nA 1.5 nA 15 nA 150 nA 1.3 μ A 1.9 μ A 21 μ A 42 μ A 94 μ A 35 mA 76 mA	Keysight 3458A Multimeter, Reference Resistors
Resistance Sources ¹	0 Ω	5.9 $\mu\Omega$	Keysight 34420A Multimeter
Resistance Sources ¹	1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 k Ω 1.9 k Ω 10 k Ω 19 k Ω 100 k Ω 190 k Ω	12 $\mu\Omega$ 13 $\mu\Omega$ 47 $\mu\Omega$ 99 $\mu\Omega$ 0.31 m Ω 0.55 m Ω 2.8 m Ω 3.9 m Ω 19 m Ω 57 m Ω 0.29 Ω 0.7 Ω	Keysight 3458A Multimeter, Reference Resistors
Resistance Sources ¹	1 M Ω 1.9 M Ω 10 M Ω 19 M Ω 100 M Ω	4.2 Ω 9.4 Ω 5 Ω 0.24 k Ω 2.3 k Ω	Keysight 3458A Multimeter, Reference Resistors
DC Resistance Sources, Specific Values ¹	0.1 Ω 0.48 Ω 1 Ω 4.8 Ω 10 Ω 65 Ω 100 Ω 1 k Ω	0.13 $\mu\Omega$ 0.61 $\mu\Omega$ 1.3 $\mu\Omega$ 6.7 $\mu\Omega$ 13 $\mu\Omega$ 87 $\mu\Omega$ 0.13 m Ω 1.3 m Ω	Resistance standards and bridge Ratio measurement



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Resistance Sources, Specific Values ¹	10 kΩ 100 kΩ 1 MΩ 10 MΩ 100 MΩ	13 mΩ 0.13 Ω 1.6 Ω 21 Ω 0.23 kΩ	Resistance standards and bridge Ratio measurement
DC Voltage Sources, Voltage Range ¹	(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 μV 0.74 μV 8.5 μV 74 μV 1.1 mV	Fluke 732B Voltage Standard, voltmeter, voltage divider Differential measurement
DC Current Sources, Current Range ¹	(0 to 100) μA (100 to 300) μA 300 μA 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 μA 0.97 μA 5.9 μA 82 μA/A + 3 μA 76 μA/A + 66 μA 150 μA/A + 570 μA 21 μA/A + 64 μA	Resistance standards and voltmeter Indirect measurement
AC Voltage Sources, Voltage Range ¹	1 mV to 1 kV	(See Matrix F)	Fluke 5790A Multi Product Calibrator Direct measurement
Measurement of AC Voltage Source ^{1,2}	20 Hz to 20 MHz (0 to 60) mV	(0.058*X - 0.049) mV	URE2/3 RMS Voltmeter
AC Current Sources, Current Range ¹	10 μA 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 ¹	(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 μV 2.2 μV 0.11 mV 5 mV	Generate using Fluke 5720A Multi Product Calibrator with Multimeter 3458A Direct and Indirect measurement
DC Voltage Meters ¹	0 V 100 mV 1 V	0.12 μV 63 nV 71 nV	Fluke 732A DC Reference Standard

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage Meters ¹	10 V 100 V 1 000 V	1.1 μ V 56 μ V 0.59 mV	Standard Resistors, Fluke 57X0A Calibrator, Keysight 3458A Multimeter
Resistance Meters, Fixed Value ¹	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 $\mu\Omega$ 15 $\mu\Omega$ 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
Resistance Meter ¹	Short 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	2.4 $\mu\Omega$ 1.3 $\mu\Omega$ 4.6 $\mu\Omega$ 56 $\mu\Omega$ 450 $\mu\Omega$ 5.4 m Ω 5.2 m Ω 1.5 Ω 55 Ω 2.5 k Ω 83 k Ω	Standard Resistors
DC Current Meters, Current Range ¹	(0 to100) nA 100 nA to1 μ A (1 to10) μ A (10 to100) μ A 100 μ A to1 mA (1 to10) 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



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current Meters ¹	100 nA 1 μA 10 μA 100 μA 1 mA 10 mA 100 mA 1A	0.15 pA 1.5 pA 19 pA 190 pA 1.9 nA 12 nA 0.37 μA 6.5 μA	Standard Resistors, Fluke 57X0A Calibrator, Keysight 3458A Multimeter
AC Voltage Meters, Voltage Range ¹	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 Voltage Meters ¹	10 mV 1 kHz 10 mV 20 kHz 10 mV 100 kHz 10 mV 300 kHz 10 mV 1 MHz 100 mV 1 kHz 100 mV 20 kHz 100 mV 100 kHz 100 mV 300 kHz 100 mV 1 MHz 1 V 1 kHz 1 V 20 kHz 1 V 50 kHz 1 V 100 kHz 1 V 300 kHz 1 V 500 kHz 1 V 1 MHz 3 V 100 kHz 10 V 10 Hz 10 V 20 Hz 10 V 40 Hz 10 V 1 kHz 10 V 4 kHz 10 V 8 kHz 10 V 10 kHz 10 V 20 kHz	0.14 μV 0.21 μV 0.17 μV 0.41 μV 3.2 μV 2.5 μV 2.5 μV 2.3 μV 5.4 μV 31 μV 4.6 μV 6.9 μV 7.2 μV 11 μV 28 μV 65 μV 0.29 mV 47 μV 0.47 mV 73 μV 59 μV 47 μV 0.11 mV 0.11 mV 0.11 mV 66 μV	Fluke 57X0A Calibrator, Keysight 3458A Multimeter, AC Divider, Function Generator and AC Measurement Standard

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage Meters ¹	10 V 50 kHz	80 μ V	Fluke 57X0A Calibrator, Keysight 3458A Multimeter, AC Divider, Function Generator and AC Measurement Standard
	10 V 100 kHz	0.11 mV	
	10 V 300 kHz	1.6 mV	
	10 V 500 kHz	0.95 mV	
	10 V 1 MHz	4.1 mV	
	100 V 1 kHz	0.89 mV	
	100 V 20 kHz	0.89 mV	
	100 V 50 kHz	0.99 mV	
	100 V 100 kHz	3.7 mV	
	700 V 1 kHz	18 mV	
	700 V 20 kHz	44 mV	
	1 000 V 10 kHz	16 mV	
	1 000 V 20 kHz	25 mV	
	10 mV 4 MHz	11 μ V	
	100 mV 4 MHz	0.11 mV	
	100 mV 8 MHz	0.17 mV	
	100 mV 10 MHz	0.2 mV	
	1 V 4 MHz	1.1 mV	
	1 V 8 MHz	1.7 mV	
	1 V 10 MHz	2.2 mV	
3 V 2 MHz	2.2 mV		
3 V 4 MHz	3.3 mV		
3 V 8 MHz	5 mV		
3 V 10 MHz	6.4 mV		
AC Current Meters Current Range ¹	Up to 10 μ A 45 Hz to 1 kHz	4.2 nA	Generate using Fluke 5720A Multi Product Calibrator with Multimeter 3458A Direct Measurement
	(10 to 100) μ A 45 Hz to 1 kHz	11 nA	
	100 μ A to 1 mA 45 Hz to 1 kHz	0.11 μ A	
AC Current Meters Current Range ¹	(1 to 10) mA 45 Hz to 1 kHz	1.1 μ A	Generate using Fluke 5720A Multi Product Calibrator with Multimeter 3458A Direct Measurement
	(10 to 100) mA 45 Hz to 1 kHz	11 μ A	
	100 mA to 1 A 45 Hz to 1 kHz	190 μ A	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current Meter ¹ 1 kHz	10 μ A	1.4 nA	Fluke 57X0A Calibrator
	100 μ A	9.2 nA	
	1 mA	75 nA	
	10 mA	740 nA	
	100 mA	7.7 μ A	
	1 A	88 μ A	
4T Capacitance meter ¹	1 pF		Measure using 16380A /16380C Capacitor Set
	(20 to 100) Hz	15 fF	
	100 Hz to 1 kHz	0.84 fF	
	1 kHz	0.12 fF	
	1 kHz to 1 MHz	0.56 fF	
	1 MHz	0.14 fF	
	(1 to 2) MHz	0.58 fF	
	2 MHz	0.25 fF	
	10 pF		
	(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		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
4T Capacitance meter ¹	10 nF		Measure using 16380A /16380C Capacitor Set
	(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	
	1 μF		
	(20 to 120) Hz	2.4 nF	
	120 Hz	55 pF	
	1 kHz	47 pF	
	10 kHz	47 pF	
	100 kHz	89 pF	
	10 μF		
	(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 ^{1,3}	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	



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
4T Dissipation meter ^{1,3}	100 pF		Measure using 16380A /16380C Capacitor Set
	(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	
	1 000 pF		
	(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		



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
4T AC Resistance meter ¹	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 mΩ	
	2 MHz	5.2 mΩ	
	100 Ω		
	(20 to 100) Hz	51 mΩ	
	100 Hz to 1 MHz	51 mΩ	
	1 MHz	31 mΩ	
	(1 to 2) MHz	57 mΩ	
	2 MHz	41 mΩ	
	1 kΩ		
	(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 kΩ		
	(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 kΩ			
(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
Voltage Range	Uncertainty = $u_1 \times \mu\text{V}/\text{V} + u_2 \mu\text{V} \times \text{is voltage in V}$							
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					
Voltage Range	Frequency (kHz)					
	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
Time Interval Measure ¹	(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 Source ¹	10 MHz	1.3×10^{-11} Hz/Hz	5071A Frequency Standard
Frequency Measure ¹	10 MHz	1.4×10^{-11} Hz/Hz	53132A Counter phase locked to 5071A
Frequency Source ¹	(0.1 to 1) Hz (1 to 10) Hz (10 to 100) Hz 100 Hz to 100 kHz 100 kHz to 10 MHz (10 to 100) MHz	67 pHz 0.88 nHz 4.7 nHz $1.6 \times 10^{-11} \cdot f$ $1.6 \times 10^{-11} f + 96$ nHz $1.6 \times 10^{-11} f$	Function Generator 33250A, Signal Generator E8257D
	100 MHz to 45 GHz	1.5×10^{-11} Hz/Hz	Signal Analyzer E4448A Frequency Standard 5071A Frequency Standard Differential measurement

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Measure ¹	(0.1 to 1) Hz 1 Hz to 250 kHz 250 kHz to 1 MHz (1 to 100) MHz	$2 \times 10^{-6} f + 0.43 \mu\text{Hz}$ $2.4 \cdot 10^{-6} f$ $5.2 \cdot 10^{-9} f + 0.14 \text{ mHz}$ $5.3 \cdot 10^{-9} f$	Frequency Counter 53132A
	1 MHz 100 MHz	30 μHz 0.58 mHz	Measure using counter 53131/32A. Frequency source use, Signal Generator 83650B and E8257D


Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Digital Indicators ¹	Up to 70 mm (> 70 to 100) mm	0.002 6 mm 0.002 7 mm	Grade 0 Gage Blocks, Gage Stand
Dial Indicators ¹	Up to 10 mm (> 10 to 100) mm	0.003 5 mm 0.003 6 mm	Grade 0 Gage Blocks, Gage Stand
Feeler Gage ¹	(0.03 to 3.00) mm	0.002 2 mm	Micrometer

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, D = distortion, T = transmission, X = voltage in millivolts.
3. Unitless linear measure.
4. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-1928.



Vice President

