

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

**LABORATORY LOCATION: KEYSIGHT TECHNOLOGIES MALAYSIA SDN. BHD.
(PERMANENT LABORATORY) (FORMERLY KNOWN AS AGILENT TECHNOLOGIES
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This laboratory accredited under *Skim Akreditasi Makmal Malaysia* (SAMM) meets the requirements of MS ISO/IEC 17025:2005 'General requirements for competence of testing and calibration laboratories'. This Malaysian Standards is identical with ISO/IEC 17025:2005 published by the International Organization for Standardization (ISO).

*** The expanded uncertainties are based on an estimated confidence probability of approximately 95% and have a coverage factor of k=2 unless stated otherwise.**

^[1]Linear voltage reflection and transmission coefficient measurement

^[2]The CMC is expressed as \pm (of indication in nV/V + floor value in nV)

^[3]iPIMMS is an 'industry' primary impedance measurement service supplied and maintained by UK's National Physical Laboratory.

^[4]The %/% in CMC expresses the uncertainty of measured value (reading in %).

^[5]The CMC is expressed as uncertainty (%/%) of indication (%) + floor value in %.

FIELD OF CALIBRATION: ELECTRICAL – RF/Microwave (50 Ω System)

SCOPE OF ACCREDITATION:

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (\pm)*	Remarks
Power Sources Fitted with female Type-N connectors	1 mW at 50 MHz	2.2 μ W	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	1 kHz intermediate frequency substitution method
	1 MHz to 80 MHz 0 dB to 40 dB 40 dB to 80 dB 80 dB to 110 dB	0.005 dB 0.010 dB 0.030 dB	

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

FIELD OF CALIBRATION: ELECTRICAL – RF/Microwave (50 Ω System)

SCOPE OF ACCREDITATION:

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (\pm)*	Remarks
Passive Devices Scalar Attenuation, Measure (Continues) Passive Devices Scattering Parameter: Reflection coefficient (linear)	80 MHz to 6 GHz 0 dB to 40 dB 40 dB to 80 dB 80 dB to 110 dB 10 kHz to 300 kHz 0 to 0.1 0.1 to 0.5 0.5 to 1.0 300 kHz to 6 GHz 0 to 0.1 0.1 to 0.5 0.5 to 1.0 45 MHz to 50 GHz (See Matrix A)	 0.010 dB 0.021 dB 0.032 dB 0.0022 0.0028 0.0055 0.0018 0.0024 0.0052 (See Matrix A)	 Measure using HP8753ES, 85054B ^[1] Measure using E8364B/C
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 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 45 MHz to 50 GHz (See Matrix B)	 0.062 dB 0.072 dB 0.13 dB 0.057dB 0.060dB 0.061dB 0.073 dB 0.090 dB 0.098 dB 0.15 dB 0.38 dB (See Matrix B)	Measure using HP8753ES, 85054B Measure using E8364B/C

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

FIELD OF CALIBRATION: ELECTRICAL – RF/Microwave (50 Ω System)

SCOPE OF ACCREDITATION:

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (±)*	Remarks
Power Sensor, Calibration Factors	<p>100 pW to 1 μW 10 MHz to 50 MHz 50 MHz to 18 GHz 18 GHz to 26.5 GHz 26.5 GHz to 50 GHz</p> <p>1 μW to 100 μW 9 kHz to 100 kHz 100 kHz to 10 MHz 10 MHz to 50 MHz 50 MHz to 4.2 GHz 4.2 GHz to 18 GHz 18 GHz to 26.5 GHz 26.5 GHz to 50 GHz</p> <p>100 μW to 10 mW 9 kHz to 100 kHz 100 kHz to 10 MHz 10 MHz to 50 MHz 50 MHz to 4.2 GHz 4.2 GHz to 18 GHz 18 GHz to 26.5 GHz 26.5 GHz to 50 GHz</p>	<p>0.35 % 0.35 % 1.3 % 1.3 %</p> <p>0.40 % 0.30 % 0.30 % 0.30 % 0.32 % 1.0 % 1.3 %</p> <p>0.40 % 0.30 % 0.30 % 0.30 % 0.32 % 1.0 % 1.3 %</p>	Reference to 1 mW at 50 MHz

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

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Power Sensor, Calibration Factors (continue)	10 mW to 100 mW		
	9 kHz to 100 kHz	0.40 %	
	100 kHz to 10 MHz	0.30 %	
	10 MHz to 50 MHz	0.30 %	
	50 MHz to 4.2 GHz	0.30 %	
	4.2 GHz to 18 GHz	0.32 %	
	18 GHz to 26.5 GHz	1.0 %	
	26.5 GHz to 50 GHz	1.3 %	
	100 mW to 3 W		
	100 kHz to 10 MHz	0.30 %	
	10 MHz to 4.2 GHz	0.30 %	
	4.2 GHz to 18 GHz	0.33 %	
75 Ω System	1 μW to 100 mW		
	100 kHz to 2 GHz	0.97 %	
Frequency Sources	10 MHz	1.3×10^{-11} Hz/Hz	Measure using HP5071A, 53132A

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	$0.0109x^2 + 0.0121x + 0.0106$	

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

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/C 85052B
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	
45 MHz to 2 GHz	0.022	0.029	0.036	0.046	0.058	0.076	0.102	0.178	Using E8364B/C 85056A
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	

Signatories:

1. Yong En Haur
2. Tan Ming Hui
3. Kee Kah Ghim
4. Cheong Chee Seng

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

FIELD OF CALIBRATION: ELECTRICAL – RF/Microwave (50 Ω System)

SCOPE OF ACCREDITATION:

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (\pm)*	Remarks
Scattering Parameter: 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	 0.0030 ^[1] 0.0040 ^[1]	Measure using iPIMMS ^[3]
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	 0.0002 dB 0.0088 dB 0.018 dB 0.027 dB 0.037 dB 0.056 dB 0.12 dB 0.34 dB 1.0 dB 2.9 dB	Measure using iPIMMS ^[3]

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of
SAMM 248 dated 2 April 2014)

Page: 7 of 25

FIELD OF CALIBRATION: ELECTRICAL – RF/Microwave (50 Ω System)

SCOPE OF ACCREDITATION:

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (\pm)*	Remarks
Scattering Parameter: Transmission Coefficient, T (continue)			
Passive Devices fitted 3.5 mm connectors	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	0.0002 dB 0.0088 dB 0.018 dB 0.027 dB 0.037 dB 0.056 dB 0.12 dB 0.34 dB 1.0 dB 2.9 dB	

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NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

FIELD OF CALIBRATION: ELECTRICAL – RF & Microwave (50 Ω System) for Signal Source
SCOPE OF ACCREDITATION:

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (±)*	Remarks
Signal Sources - Absolute RF Power in Coaxial	<p>1 nW to 100 mW 9 kHz to 6 GHz</p> <p>10 nW to 1 W 9 kHz to 18 GHz</p> <p>10 nW to 1 W 9 kHz to 24 GHz</p> <p>1 μW to 100 mW 50 MHz to 50 GHz</p> <p>1 fW to 3.16 μW 9 kHz to 50 GHz</p>	<p>28mW/W</p> <p>29 mW/W</p> <p>41 mW/W</p> <p>17 mW/W</p> <p>23 mW/W</p>	<p>Agilent E9304A</p> <p>Agilent E9304A H19</p> <p>Agilent E9304A H25</p> <p>Agilent 8487A</p> <p>Agilent E9304A Agilent 8487A Agilent E4448A</p>
Signal Sources - Harmonic Content	<p>Fundamental Frequency 1 MHz to 25 GHz 0 to 10 dBm Harmonic Frequency 2 MHz to 50 GHz -110 dBm to 0 dBm</p>	<p>0.51 dB</p>	<p>Agilent E4448A</p>
Signal Sources - Pulse Time Parameters Rise/Fall Time	<p>0 to 10 dBm 10 MHz to 50 GHz</p>	<p>86 ps</p>	<p>Agilent 86100C Agilent 86117A</p>

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

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Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (\pm)*	Remarks
Signal Sources – Modulation Frequency Modulation Peak Frequency Deviation	<p>-18 to 30 dBm</p> <p>f_c: 250 kHz to 10 MHz f_m: 20 Hz to 10 kHz Δf: 200 Hz to 40 kHz $\beta > 0.2$</p> <p>f_c: 250 kHz to 10 MHz f_m: 20 Hz to 10 kHz Δf: 200 Hz to 40 kHz $\beta > 1.2$</p> <p>f_c: 10 MHz to 6.6 GHz f_m: 50 Hz to 200 kHz Δf: 250 Hz to 400 kHz $\beta > 0.2$</p> <p>f_c: 10 MHz to 6.6 GHz f_m: 50 Hz to 200 kHz Δf: 250 Hz to 400 kHz $\beta > 0.45$</p> <p>f_c: 6.6 GHz to 13.2 GHz f_m: 50 Hz to 200 kHz Δf: 250 Hz to 400 kHz $\beta > 0.2$</p> <p>f_c: 6.6 GHz to 13.2 GHz f_m: 50 Hz to 200 kHz Δf: 250 Hz to 400 kHz $\beta > 8$</p> <p>f_c: 13.2 GHz to 31.15 GHz f_m: 50 Hz to 200 kHz Δf: 250 Hz to 400 kHz $\beta > 0.2$</p>	<p>0.015 Hz/Hz</p> <p>0.010 Hz/Hz</p> <p>0.015 Hz/Hz</p> <p>0.010 Hz/Hz</p> <p>0.025 Hz/Hz</p> <p>0.010 Hz/Hz</p> <p>0.038 Hz/Hz</p>	<p>Agilent E4448A f_c = Carrier Frequency f_m = Modulation Rate Δf=Peak Deviation $\beta = \Delta f / f_m$</p>

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

FIELD OF CALIBRATION: ELECTRICAL – RF & Microwave (50 Ω System) for Signal Source

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Signal Sources – Modulation Frequency Modulation Peak Frequency Deviation (continue)	<p>f_c: 13.2 GHz to 31.15 GHz f_m: 50 Hz to 200 kHz Δf: 250 Hz to 400 kHz $\beta > 16$</p> <p>f_c: 31.15 GHz to 50 GHz f_m: 50 Hz to 200 kHz Δf: 250 Hz to 400 kHz $\beta > 0.2$</p> <p>f_c: 31.15 GHz to 50 GHz f_m: 50 Hz to 200 kHz Δf: 250 Hz to 400 kHz $\beta > 32$</p>	<p>0.010 Hz/Hz</p> <p>0.085 Hz/Hz</p> <p>0.010 Hz/Hz</p>	
Amplitude Modulation Depth	<p>-18 to 30 dBm</p> <p>f_m: 50 Hz to 100 kHz</p> <p>f_c: 100 kHz to 10 MHz Depth: 5 % to 99 %</p> <p>f_c: 10 MHz to 3 GHz Depth: 20 % to 99 %</p> <p>f_c: 10 MHz to 3 GHz Depth: 5 % to 20 %</p> <p>f_c: 3 GHz to 26.5 GHz Depth: 20 % to 99 %</p> <p>f_c: 3 GHz to 26.5 GHz Depth: 5 % to 20 %</p> <p>f_c: 26.5 GHz to 31.15 GHz Depth: 20 % to 99 %</p>	<p>0.0075 %/‰^[4]</p> <p>0.005 %/‰^[4]</p> <p>0.025 %/‰^[4]</p> <p>0.015 %/‰^[4]</p> <p>0.045 %/‰^[4]</p> <p>0.019 %/‰^[4]</p>	<p>Agilent E4448A f_c = Carrier Frequency f_m = Modulation Rate</p>

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

FIELD OF CALIBRATION: **ELECTRICAL – RF & Microwave (50 Ω System) for Signal Source**

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Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (\pm)*	Remarks
Amplitude Modulation (continue)	f _c : 26.5 GHz to 31.15 GHz Depth: 5 % to 20 % f _c : 31.15 GHz to 50 GHz Depth: 5 % to 20 % f _c : 31.15 GHz to 50 GHz Depth: 5 % to 20 %	0.068 %/° ^[4] 0.06 %/° ^[4] 0.26 %/° ^[4]	Agilent E4448A f _c = Carrier Frequency f _m = Modulation Rate
Phase Modulation 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 GHz to 13.2 GHz $\Delta\Phi > 2.0$ rad f _c : 6.6 GHz to 13.2 GHz $\Delta\Phi > 0.6$ rad f _c : 13.2 GHz to 26.5 GHz $\Delta\Phi > 4.0$ rad f _c : 13.2 GHz to 26.5 GHz $\Delta\Phi > 1.2$ rad f _c : 26.5 GHz to 31.15 GHz $\Delta\Phi > 4.0$ rad f _c : 26.5 GHz to 31.15 GHz $\Delta\Phi > 1.3$ rad f _c : 31.15 GHz to 50 GHz $\Delta\Phi > 8$ rad f _c : 31.15 GHz to 50 GHz $\Delta\Phi > 2.4$ rad	0.01 rad/rad 0.03 rad/rad 0.01 rad/rad 0.03 rad/rad 0.01 rad/rad 0.03 rad/rad 0.01 rad/rad 0.03 rad/rad	Agilent PSA E4448A f _c = Carrier Frequency $\Delta\Phi$ = Phase Deviation

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

FIELD OF CALIBRATION: ELECTRICAL – RF & Microwave (50 Ω System) for Signal Source
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Modulation Rate Amplitude Modulation Rate Frequency Modulation Rate Phase Modulation Rate	100 kHz \leq f_c < 50 GHz Depth \geq 20% $f_m \leq$ 100 kHz $\beta \geq$ 0.01 $f_m \leq$ 200 kHz $\beta \geq$ 0.01 $f_m \leq$ 20 kHz	 0.062 Hz 0.062 Hz 0.062 Hz	Agilent E4448A $\beta = \Delta f / f_m$ $f_m =$ Modulation Rate
Signal Sources - Modulation Distortion Amplitude Modulation Distortion	0.01% to 100% f_m : 20 Hz to 1 kHz f_c : 0.1 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 %	 0.0012 %/% + 0.8 % ^[5] 0.0012 %/% + 0.3 % ^[5] 0.0012 %/% + 1.0 % ^[5] 0.0012 %/% + 0.4 % ^[5] 0.0012 %/% + 6.2 % ^[5] 0.0012 %/% + 2.0 % ^[5] 0.0012 %/% + 1.5 % ^[5]	Agilent E4448A $f_c =$ Carrier Frequency $f_m =$ Modulation Rate

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

FIELD OF CALIBRATION: ELECTRICAL – RF & Microwave (50 Ω System) for Signal Source
SCOPE OF ACCREDITATION:

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (\pm)*	Remarks
Signal Sources - Modulation Distortion (continue) Phase Modulation Distortion	f _c : 1 MHz to 6.6 GHz f _m : 20 Hz to 500 Hz $\Delta\Phi > 0.8$ rad $\Delta\Phi \geq 2.5$ rad	0.0012 %/% + 0.3 % ^[5] 0.0012 %/% + 0.1 % ^[5]	Agilent E4448A f _c =Carrier Frequency f _m = Modulation Rate
	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	0.0012 %/% + 0.3 % ^[5] 0.0012 %/% + 0.1 % ^[5]	
	f _c : 6.6 GHz to 13.2 GHz f _m : 20 Hz to 500 Hz $\Delta\Phi > 1.8$ rad $\Delta\Phi \geq 5.5$ rad	0.0012 %/% + 0.3 % ^[5] 0.0012 %/% + 0.1 % ^[5]	
	f _c : 6.6 GHz to 13.2 GHz f _m : 500 Hz to 1 kHz $\Delta\Phi > 0.8$ rad $\Delta\Phi \geq 2.5$ rad	0.0012 %/% + 0.3 % ^[5] 0.0012 %/% + 0.1 % ^[5]	
	f _c : 13.2 GHz to 31.15 GHz f _m : 20 Hz to 500 Hz $\Delta\Phi > 3.5$ rad $\Delta\Phi \geq 10.0$ rad	0.0012 %/% + 0.3 % ^[5] 0.0012 %/% + 0.1 % ^[5]	
	f _c : 13.2 GHz to 31.15 GHz f _m : 500 Hz to 1 kHz $\Delta\Phi > 1.2$ rad $\Delta\Phi \geq 4.0$ rad	0.0012 %/% + 0.3 % ^[5] 0.0012 %/% + 0.1 % ^[5]	
	f _c : 31.15 GHz to 50 GHz f _m : 20 Hz to 500 Hz $\Delta\Phi > 7.5$ rad $\Delta\Phi \geq 19.0$ rad	0.0012 %/% + 0.3 % ^[5] 0.0012 %/% + 0.1 % ^[5]	
	f _c : 31.15 GHz to 50 GHz f _m : 500 Hz to 1 kHz $\Delta\Phi > 3.0$ rad $\Delta\Phi \geq 8.0$ rad	0.0012 %/% + 0.3 % ^[5] 0.0012 %/% + 0.1 % ^[5]	

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

FIELD OF CALIBRATION: ELECTRICAL – RF & Microwave (50 Ω System) for Signal Source
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Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (\pm)*	Remarks
Signal Sources - Modulation Distortion (continue) Frequency Modulation Distortion	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	0.0012 %/% + 0.3 % ^[5] 0.0012 %/% + 0.1 % ^[5]	Agilent E4448A f _c =Carrier Frequency f _m = Modulation Rate
	f _c : 6.6 GHz to 13.2 GHz f _m : 20 Hz to 1 kHz Δf > 2.3 kHz Δf ≥ 4.5 kHz	0.0012 %/% + 0.3 % ^[5] 0.0012 %/% + 0.1 % ^[5]	
	f _c : 13.2 GHz to 31.15 GHz f _m : 20 Hz to 1 kHz Δf > 2.7 kHz Δf ≥ 6.0 kHz	0.0012 %/% + 0.3 % ^[5] 0.0012 %/% + 0.1 % ^[5]	
	f _c : 31.15 GHz to 50 GHz f _m : 20 Hz to 1 kHz Δf > 4.0 kHz Δf ≥ 12.0 kHz	0.0012 %/% + 0.3 % ^[5] 0.0012 %/% + 0.1 % ^[5]	

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

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Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (±)*	Remarks
Signal Sources -Digital Modulation Carrier: 2 MHz to 2.65 GHz Error Vector Magnitude for Modulation Types: MSK, GMSK, BPSK, DQPSK, π/4DQPSK, 8PSK, 16QAM and 32QAM, QPSK Phase Error for Modulation Types: MSK, GMSK, BPSK, DQPSK, π/4DQPSK, 8PSK, 16QAM and 32QAM, QPSK Error Vector Magnitude for FSK Modulation	Mod Frequency Span: (1 to 100) kHz (0.1 to 1) MHz 1 MHz to 2.65 GHz (1 to 100) kHz (0.1 to 1) MHz 1 MHz to 2.65 GHz Mod Frequency: 3.2 kHz 1.152 kHz	0.31 % rms 0.51 % rms 1.1 % rms 0.18 ° rms 0.35 ° rms 0.58 ° rms 0.51 % rms 1.60 % rms	Agilent 89441A vector signal analyzer
Signal Sources -Phase Noise	Power level: 0dBm to 15dBm f _c : 50 kHz-1600 MHz f offset: 0.1 Hz to 1 MHz Power level: 0dBm to 15dBm f _c : 1.2 to 26.5 GHz f offset: 0.1 Hz to 1 MHz	2.4 dBc/Hz 2.4 dBc/Hz	Agilent N5500A
Signal Sources – Frequency	100 MHz to 45 GHz	9.6 × 10 ⁻¹² Hz/Hz	Agilent E4448A HP 5071A

Signatories:

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NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

FIELD OF CALIBRATION: **ELECTRICAL – RF & Microwave (50 Ω System) for Signal Analyzers**

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Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (±)*	Remarks
Signal Analyzers – Absolute RF Power in Coaxial Line	100 pW to 10 μW 10 MHz to 18 GHz	22 mW/W	Signal Source E8257D, Power Splitters, Power Meters Power Sensors Power Sensor 8481D
	1 μW to 1 mW 100 kHz to 4.2 GHz	13 mW/W	Power Sensor 8482A
	1 μW to 1 mW 10 MHz to 18 GHz	13 mW/W	Power Sensor 8481A
	1 μW to 1 mW 50 MHz 26.5 Hz	18 mW/W	Power Sensor 8485A
	100 pW to 10 μW 50 MHz 26.5 Hz	40 mW/W	Power Sensor 8485D
	1 μW to 1 mW 50 MHz 50 GHz	18 mW/W	Power Sensor 8487A
	100 pW to 10 μW 50 MHz 50 GHz	39 mW/W	Power Sensor 8487D
	1 μW to 1 mW 100 kHz to 3 GHz (75 Ω system)	16 mW/W	Power Sensor 8483A

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of
SAMM 248 dated 2 April 2014)

Page: 17 of 25

FIELD OF CALIBRATION: ELECTRICAL – RF & Microwave (50 Ω System) for
Signal Analyzers

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Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (\pm)*	Remarks
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 0.040 dB	Signal Source E8257D, Step Attenuators
Signal Analyzers, Frequency Counters – Frequency	100 MHz to 50 GHz	1.4×10^{-11} Hz/Hz	Signal Source E8257D, Frequency Standard 5071A
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

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SCOPE OF ACCREDITATION:

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (\pm)*	Remarks
<p>CISPR 16-1-1 Detectors</p> <p style="text-align: center;">Response of Quasi-peak, peak, average, RMS</p> <p>at 50 Ω system</p> <p>Pulse Spectral Density</p>	<p>13.50 μVs 1.350 μVs Band A (9 to 150) kHz PRF¹: 25 Hz</p> <p>0.3160 μVs 0.0316 μVs Band B (0.15 to 30) MHz PRF¹: 100 Hz</p> <p>0.0440 μVs Band C,D (30 to 480) MHz Band C,D (500 to 1000) MHz PRF¹: 100 Hz</p> <p>0.0044 μVs Band C,D (30 to 480) MHz Band C,D (500 to 1000) MHz PRF¹: 100 Hz</p>	<p>0.27 dB 0.26 dB</p> <p>0.26 dB 0.26 dB</p> <p>0.28 dB 0.33 dB</p> <p>0.27 dB 0.32 dB</p>	<p>Pulse Generator IGUU 2916</p> <p>PRF¹ = pulse repetitive frequency</p>

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

FIELD OF CALIBRATION: ELECTRICAL – RF & Microwave (50 Ω System) for Signal Analyzers

SCOPE OF ACCREDITATION:

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (±)*	Remarks
<p>CISPR 16-1-1 Detectors</p> <p>Response of Quasi-peak, peak, average, RMS</p> <p>at 50 Ω system (continue)</p> <p>Sine Wave</p> <p>Pulse Spectral Density relative to PRF¹</p>	<p>60 dBμV 100 kHz, 1 MHz, 10 MHz, 100 MHz</p> <p>Pulse Level²: 60 dBμV PRF¹: (0.1 to 200) Hz Band A relative to 25 Hz B,C,D relative to 100 Hz</p> <p>Pulse Level²: 40 dBμV PRF¹: 0.1 Hz to 20 kHz Band A relative to 25 Hz B,C,D relative to 100 Hz</p>	<p>0.16 dB</p> <p>0.11 dB</p> <p>0.11dB</p>	<p>Pulse Generator IGUU 2916</p> <p>Note 2: Pulse level for CISPR weighting quasi-peak</p>

Signatories:

1. Yong En Haur

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

FIELD OF CALIBRATION: ELECTRICAL – DC & Low Frequency

SCOPE OF ACCREDITATION:

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (\pm)*	Remarks
DC Sources, DC Voltmeters	150 μ V to 10 V	5 nV/V + 100 nV ^[2]	Josephson Voltage Standard
DC Resistance Sources Specific Values	0.1 Ω 0.48 Ω 1 Ω 4.8 Ω 10 Ω 65 Ω 100 Ω 1 k Ω 10 k Ω 100 k Ω 1 M Ω 10 M Ω 100 M 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 13 m Ω 0.13 Ω 1.6 Ω 21 Ω 0.23 k Ω	Measure using resistance standards and bridge
DC Voltage Sources Voltage Range	(0 to 0.1) V (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1000) V	240 nV 740 nV 8.5 μ V 74 μ V 1.1 mV	Measure using Fluke 732B, voltmeter, voltage divider
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	380 pA 810 pA 3.4 nA 7.3 nA 37 nA 85 nA 620 nA 970 nA 5.9 μ A	Measure using resistance standards and voltmeter
AC Voltage Sources Voltage Range	1 mV to 1000 V (See Matrix C)	(See Matrix C)	Measure using Fluke 5790A
AC Current Sources Current Range	10 μ A to 1 A (See Matrix D)	(See Matrix D)	Measure using Fluke 5790A with ac current shunts

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

Matrix C
AC Voltage Sources

Voltage Range	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 = $u_1 \times \mu\text{V}/\text{V} + u_2 \mu\text{V}$ x 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 1000) V	-	34x + 370	30x + 440	-	-	-	-	-

Matrix D
AC Current Sources

Current Range	Frequency (kHz)				
	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

Signatory:

1. Yong En Haur

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

FIELD OF CALIBRATION: ELECTRICAL – DC & Low Frequency

SCOPE OF ACCREDITATION:

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (\pm)*	Remarks
DC Voltage Meters Voltage Range	(0 to 0.1) V (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1000) V	95 nV 770 nV 2.2 μ V 110 μ V 5.0 mV	Generate using Fluke 5720A with Agilent 3458A
Resistance Meters Resistor Range	(0 to 1) Ω (1 to 10) Ω (10 to 100) Ω 100 Ω to 1 k Ω (1 to 10) k Ω (10 to 100) k Ω 100 k Ω to 1 M Ω (1 to 10) M Ω (10 to 100) M Ω 100 M Ω to 1 G Ω	4.8 $\mu\Omega$ 15 $\mu\Omega$ 130 $\mu\Omega$ 1.3 m Ω 8.2 m Ω 120 m Ω 30 Ω 190 Ω 850 Ω 160 k Ω	Generate using Fluke 5720A with Agilent 3458A
DC Current Meters Current Range	(0 to 100) nA (0.1 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 41.0 pA 480 pA 3.1 nA 26 nA 350 nA 43 μ A	Generate using Fluke 5720A with Agilent 3458A
AC Voltage Meters Voltage Range	10 mV to 1000 V (See Matrix E)	(See Matrix E)	Generate using Fluke 5720A, Agilent 3325B with Agilent 3458A

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of SAMM 248 dated 2 April 2014)

FIELD OF CALIBRATION: ELECTRICAL – DC & Low Frequency

SCOPE OF ACCREDITATION:

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (\pm)*	Remarks
AC Current Meters Current Range	(0 to 10) μ A 45 Hz to 1 kHz	4.2 nA	Generate using Fluke 5720A with Agilent 3458A
	(10 to 100) μ A 45 Hz to 1 kHz	11 nA	
	100 μ A to 1 mA 45 Hz to 1 kHz	110 nA	
	(1 to 10) mA 45 Hz to 1 kHz	1.1 μ A	
	(10 to 100) mA 45 Hz to 1 kHz	11.0 μ A	
	100 mA to 1 A 45 Hz to 1 kHz	190.0 μ A	
Frequency Meters Specific Values	1 Hz 10 MHz	60 μ Hz 70 Hz	Generate using Agilent 3325B

Matrix E

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 μ V	3 μ V	-	5 μ V
100 mV to 1 V	-	15 μ V	13 μ V	16 μ V	26 μ V	51 μ V
(1 to 10) V	140 μ V	140 μ V	100 μ V	260 μ V	1.4 mV	560 μ V
(10 to 100) V	-	2.4 mV	2.1 mV	2.0 mV	1.9 mV	-
(100 to 750) V	-	13.0 mV	81 mV	-	-	-

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of
SAMM 248 dated 2 April 2014)

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 μ V	4.7 μ V	52.0 μ V	-	-
(10 to 100) mV	11 μ V	58 μ V	520 μ V	990 μ V	1.2 mV
100 mV to 1 V	74 μ V	-	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	-	-	-	-

Signatories:

1. Lau Chee Keong
2. Yong En Haur

NO: SAMM 248

(Issue 2, 7 August 2014 replacement of
SAMM 248 dated 2 April 2014)

FIELD OF CALIBRATION DIMENSIONAL

SCOPE OF ACCREDITATION:

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability expressed as an uncertainty (\pm)*	Remarks
Plain Plug Gages	0.5 mm to 12 mm	0.7 μ m	Measure using Supermicrometer with laser interferometer and master cylinder gauge
Thread plug gages Pitch Diameter (metric threads, 0.2 – 6 mm pitch)	1.0 mm to 15 mm	2.0 μ m	Measure using Supermicrometer with laser interferometer, master cylinder gauge and thread wire gauge.

Signatories:

1. **Khoo Teng Kok**
2. **Ng Wei Lih**