

NO: SAMM 248

(Issue 2, 6 April 2009 replacement of SAMM 248 dated 9 June 2008)

LABORATORY LOCATION: AGILENT TECHNOLOGIES MICROWAVE
(PERMANENT LABORATORY) PRODUCTS (M) SDN BHD
BAYAN LEPAS FREE INDUSTRIAL ZONE
11900 PENANG
MALAYSIA

The standard used for assessment of this laboratory is MS ISO/IEC 17025:2005

FIELD OF CALIBRATION: ELECTRICAL

SCOPE OF ACCREDITATION:

<u>Instrument Calibrated/ Measurement Parameter</u>	<u>Range</u>	<u>Best measurement capability expressed as an uncertainty (±) *</u>
1. RF Power (Measure)	1 mW , 50 MHz	0.38%
2. RF / Microwave Attenuation (Measure) (1 kHz; IF Substitution Method)	1.01 kHz to 1 MHz	
	0 dB to 40 dB	0.0090 dB
	41 dB to 80 dB	0.022 dB
	81 dB to 110 dB	0.033 dB
	1 MHz to 80 MHz	
	0 dB to 40 dB	0.0050 dB
	41 dB to 80 dB	0.010 dB
	81 dB to 110 dB	0.030 dB
	80 MHz to 6 GHz	
	0 dB to 40 dB	0.010 dB
	41 dB to 80 dB	0.021 dB
	81 dB to 110 dB	0.032 dB

* The uncertainties are based on an estimated confidence probability of not less than 95% unless otherwise stated.



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<u>Instrument Calibrated/ Measurement Parameter</u>	<u>Range</u>	<u>Best measurement capability expressed as an uncertainty (\pm) *</u>
3. Voltage Reflection Coefficient S11/S22 (Linearity) (Measure - 50 ohm system)	10 kHz to 300 kHz	
	0 to 0.1	0.0022
	0.1 to 0.5	0.0028
	0.5 to 1.0	0.0055
	300 kHz to 6 GHz	
	0 to 0.1	0.0018
	0.1 to 0.5	0.0024
	0.5 to 1.0	0.0052
	45 MHz to 18 GHz	
	0 to 0.1	0.0030
	0.1 to 0.5	0.0032
	0.5 to 1.0	0.0049
18 GHz to 26.5 GHz		
0 to 0.1	0.0045	
0.1 to 0.5	0.0047	
0.5 to 1.0	0.0079	
26.5 GHz to 50 GHz		
0 to 0.1	0.0086	
0.1 to 0.5	0.0087	
0.5 to 1.0	0.012	



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4. Transmission S12/S21 (Measure- 50 ohm system)	10 kHz to 30 kHz	
	0 dB to 10 dB	0.062 dB
	10 dB to 20 dB	0.072 dB
	20 dB to 30 dB	0.13 dB
	30 kHz to 6 GHz	
	0 dB to 10 dB	0.057dB
	10 dB to 20 dB	0.060dB
	20 dB to 30 dB	0.061dB
	30 dB to 40 dB	0.073 dB
	40 dB to 50 dB	0.090 dB
	50 dB to 60 dB	0.098 dB
	60 dB to 70 dB	0.15 dB
	70 dB to 80 dB	0.38 dB
	45 MHz to 18 GHz	
	0 dB to 10dB	0.022 dB
	10 dB to 20 dB	0.023 dB
	20 dB to 30 dB	0.029 dB
	30 dB to 40 dB	0.053 dB
	40 dB to 50 dB	0.059 dB
	50 dB to 60 dB	0.083 dB
	60 dB to 70 dB	0.17 dB
	70 dB to 80 dB	0.45 dB
	18 GHz to 26.5 GHz	
	0 dB to 10 dB	0.029 dB
	10 dB to 20 dB	0.030 dB
	20 dB to 30 dB	0.035 dB
	30 dB to 40 dB	0.060 dB
40 dB to 50 dB	0.10 dB	
50 dB to 60 dB	0.12 dB	
60 dB to 70 dB	0.21 dB	
70 dB to 80 dB	0.49 dB	
26.5 GHz to 50 GHz		
0 dB to 10 dB	0.031 dB	
10 dB to 20 dB	0.032 dB	
20 dB to 30 dB	0.038 dB	
30 dB to 40 dB	0.062 dB	
40 dB to 50 dB	0.085 dB	
50 dB to 60 dB	0.14 dB	



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<u>Instrument Calibrated/ Measurement Parameter</u>	<u>Range</u>	<u>Best measurement capability expressed as an uncertainty (±) *</u>
5. Calibration Factor of RF Power, at 1 mW, 50 MHz		of reading
(Measure Power Sensors - 75 Ohm System)	1 μ W to 100 mW	
	100 kHz to 2 GHz	0.97%
(Measure Power Sensors - 50 Ohm System)	100 pW to 1 μ W	
	10 MHz to 50 MHz	0.35 %
	50 MHz to 18 GHz	0.35 %
	18 GHz to 26.5 GHz	1.3 %
	26.5 GHz to 50 GHz	1.3 %
	1 μ W to 100 μ W	
	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 μ W to 10 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 %



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<u>Instrument Calibrated/ Measurement Parameter</u>	<u>Range</u>	<u>Best measurement capability expressed as an uncertainty (\pm) *</u>
5. Calibration Factor of RF Power, at 1 mW, 50 MHz (continue)	10 mW to 100 mW	of reading
(Measure Power Sensors - 50 Ohm System)	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 %
6. Frequency Source	10 MHz	7.2E-12 Hz/Hz

Signatories:

- | | |
|---------------------|--------------------------|
| 1. Tan Phaik Geok | I/C No. : 810805-07-5582 |
| 2. Yong En Haur | I/C No. : 780510-10-5225 |
| 3. Tan Ming Hui | I/C No. : 820927-06-5859 |
| 4. Cheong Chee Seng | I/C No. : 760220-07-5621 |



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SCOPE OF ACCREDITATION:

<u>Instrument Calibrated/ Measurement Parameter</u>	<u>Range</u>	<u>Best measurement capability expressed as an uncertainty (\pm) *</u>
7. Reflection Coefficient, Γ	$-1 \leq \text{Re}\{\Gamma\} \leq 1$ $-1 \leq \text{Im}\{\Gamma\} \leq 1$ constrained by: $0 \leq \Gamma \leq 1$	
For devices fitted with Type-N connectors only.	45 MHz to 18 GHz	0.0030
For devices fitted 3.5 mm connectors.	45 MHz to 33 GHz	0.0040
8. Transmission Coefficient, T	$-1 \leq \text{Re}\{T\} \leq 1$ $-1 \leq \text{Im}\{T\} \leq 1$ constrained by: $0 \leq T \leq 1$	
For devices fitted with Type-N connectors.	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



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<u>Instrument Calibrated/ Measurement Parameter</u>	<u>Range</u>	<u>Best measurement capability expressed as an uncertainty (\pm) *</u>
8. Transmission Coefficient, T (Continue)		
For devices fitted 3.5 mm connectors.	45 MHz to 33 GHz:	
	0 dB to 10 dB	0.0002 dB
	10 dB to 20 dB	0.0088 dB
	20 dB to 30 dB	0.018 dB
	30 dB to 40 dB	0.027 dB
	40 dB to 50 dB	0.037 dB
	50 dB to 60 dB	0.056 dB
	60 dB to 70 dB	0.12 dB
	70 dB to 80 dB	0.34 dB
80 dB to 90 dB	1.0 dB	
90 dB to 100 dB	2.9 dB	

Signatories:

- 1. Tan Phaik Geok I/C No. : 810805-07-5582
- 2. Yong En Haur I/C No. : 780510-10-5225



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DC/LF Source		
9. DC Resistance	0.1 Ohm	0.13 μ Ohm
	0.48 Ohm	0.61 μ Ohm
	1 Ohm	1.3 μ Ohm
	4.8 Ohm	6.7 μ Ohm
	10 Ohm	13 μ Ohm
	65 Ohm	87 μ Ohm
	100 Ohm	0.13 mOhm
	1 kOhm	1.3 mOhm
	10 kOhm	13 mOhm
	100 kOhm	0.13 Ohm
	1 MOhm	1.6 Ohm
	10 MOhm	21 Ohm
	100 MOhm	0.23 kOhm
10. DC Voltage	0 mV to 100 mV	0.21 μ V
	100 mV to 1 V	0.74 μ V
	1 V to 10 V	7.4 μ V
	10 V to 100 V	74 μ V
	100 V to 1000 V	1.2 mV
11. DC Current	0 μ A to 100 μ A	0.38 nA
	100 μ A to 300 μ A	0.82 nA
	300 μ A to 1 mA	3.5 nA
	1 mA to 3 mA	7.4 nA
	3 mA to 10 mA	36 nA
	10 mA to 30 mA	77 nA
	30 mA to 100 mA	0.58 μ A
	100 mA to 300 mA	0.97 μ A
	300 mA to 1 A	5.9 μ A



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<u>Instrument Calibrated/ Measurement Parameter</u>	<u>Range</u>	<u>Best measurement capability expressed as an uncertainty (\pm) *</u>
DC/LF Source		
12. AC Voltage	0 mV to 2.2 mV, 10 Hz to 20 Hz	3.2 μ V
	20 Hz to 40 Hz	1.9 μ V
	40 Hz to 20 kHz	1.5 μ V
	20 kHz to 50 kHz	2.5 μ V
	50 kHz to 100 kHz	3.3 μ V
	100 kHz to 300 kHz	5.8 μ V
	300 kHz to 500 kHz	7.3 μ V
	500 kHz to 1 MHz	11 μ V
	2.2 mV to 22 mV, 10 Hz to 20 Hz	5.3 μ V
	20 Hz to 40 Hz	3.5 μ V
	40 Hz to 20 kHz	2.4 μ V
	20 kHz to 50 kHz	4.2 μ V
50 kHz to 100 kHz	5.9 μ V	
100 kHz to 300 kHz	14 μ V	
300 kHz to 500 kHz	18 μ V	
500 kHz to 1 MHz	29 μ V	
22 mV to 220 mV, 10 Hz to 20 Hz	32 μ V	
20 Hz to 40 Hz	14 μ V	
40 Hz to 20 kHz	8.4 μ V	
20 kHz to 50 kHz	13 μ V	
50 kHz to 100 kHz	24 μ V	
100 kHz to 300 kHz	37 μ V	
300 kHz to 500 kHz	59 μ V	
500 kHz to 1 MHz	0.15 mV	
220 mV to 2.2V, 10 Hz to 20 Hz	0.28 mV	
20 Hz to 40 Hz	93 μ V	
40 Hz to 20 kHz	37 μ V	
20 kHz to 50 kHz	64 μ V	
50 kHz to 100 kHz	97 μ V	
100 kHz to 300 kHz	0.22 mV	
300 kHz to 500 kHz	0.35 mV	
500 kHz to 1 MHz	1.3 mV	



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DC/LF Source		
12. AC Voltage (continue)	2.2V to 22V, 10 Hz to 20 Hz	2.8 mV
	20 Hz to 40 Hz	0.94 mV
	40 Hz to 20 kHz	0.42 mV
	20 kHz to 50 kHz	0.68 mV
	50 kHz to 100 kHz	1.1 mV
	100 kHz to 300 kHz	2.6 mV
	300 kHz to 500 kHz	5.4 mV
	500 kHz to 1 MHz	13 mV
	22V to 220 V, 10 Hz to 20 Hz	28 mV
	20 Hz to 40 Hz	9.7 mV
	40 Hz to 20 kHz	4.7 mV
	20 kHz to 50 kHz	9.7 mV
	50 kHz to 100 kHz	14 mV
	100 kHz to 300 kHz	29 mV
	220 V to 750 V, 50 kHz to 100 kHz	0.21 V
750 V to 1100 V, 40 Hz to 1 kHz	31 mV	
1 kHz to 20 kHz	29 mV	
20 kHz to 30 kHz	94 mV	



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DC/LF Source		
13. AC Current		
	0 μ A to 220 μ A, 10 Hz to 20 Hz	38 nA
	20 Hz to 40 Hz	25 nA
	40 Hz to 1 kHz	22 nA
	1 kHz to 5 kHz	22 nA
	5 kHz to 10 kHz	22 nA
	220 μ A to 2.2 mA, 10 Hz to 20 Hz	0.38 μ A
	20 Hz to 40 Hz	0.25 μ A
	40 Hz to 1 kHz	0.22 μ A
	1 kHz to 5 kHz	0.22 μ A
	5 kHz to 10 kHz	0.22 μ A
	2.2 mA to 22 mA, 10 Hz to 20 Hz	3.8 μ A
	20 Hz to 40 Hz	2.5 μ A
	40 Hz to 1 kHz	2.2 μ A
	1 kHz to 5 kHz	2.2 μ A
	5 kHz to 10 kHz	2.2 μ A
	22 mA to 220 mA, 10 Hz to 20 Hz	38 μ A
	20 Hz to 40 Hz	25 μ A
	40 Hz to 1 kHz	22 μ A
	1 kHz to 5 kHz	22 μ A
	5 kHz to 10 kHz	22 μ A
	220 mA to 2.2 A, 20 Hz to 40 Hz	0.25 mA
	40 Hz to 1 kHz	0.22 mA
	1 kHz to 5 kHz	0.22 mA
	5 kHz to 10 kHz	0.22 mA

Signatory:

1. Yong En Haur

I/C No. : 780510-10-5225



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SCOPE OF ACCREDITATION:

<u>Instrument Calibrated/ Measurement Parameter</u>	<u>Range</u>	<u>Best measurement capability expressed as an uncertainty (\pm) *</u>
DC/LF Measure		
14. DC Voltage	100 mV	0.15 μ V
	-100 mV	0.15 μ V
	1 V	1.4 μ V
	-1 V	1.5 μ V
	10 V	3.7 μ V
	-10 V	3.8 μ V
	100 V	0.27 mV
	-100 V	0.26 mV
	1000 V	5.9 mV
	-1000 V	5.9 mV
15. Resistance	1 Ohm	4.4 μ Ohm
	10 Ohm	32 μ Ohm
	100 Ohm	0.15 mOhm
	1 kOhm	1.9 mOhm
	10 kOhm	13 mOhm
	100 kOhm	0.31 Ohm
	1 MOhm	13 Ohm
	10 MOhm	0.27 kOhm
	100 MOhm	7.8 kOhm
	1 GOhm	0.96 MOhm
16. DC Current	100 nA	3.2 pA
	-100 nA	8.1 pA
	1 μ A	24 pA
	-1 μ A	24 pA
	10 μ A	0.22 nA
	-10 μ A	0.22 nA
	100 μ A	1.1 nA
	-100 μ A	1.1 nA
	1 mA	9.9 nA
	-1 mA	9.9 nA
	10 mA	0.11 μ A
	-10 mA	0.12 μ A
	100 mA	1.5 μ A
	-100 mA	1.5 μ A
	1 A	52 μ A
	-1 A	52 μ A



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<u>Instrument Calibrated/ Measurement Parameter</u>	<u>Range</u>	<u>Best measurement capability expressed as an uncertainty (\pm) *</u>
DC/LF Measure		
17. AC Voltage		
	10 mV @ 1kHz	0.65 μ V
	10 mV @ 20 kHz	0.61 μ V
	10 mV @ 100 kHz	0.62 μ V
	10 mV @ 300 kHz	1.5 μ V
	10 mV @ 1 MHz	6.0 μ V
	100 mV @ 1 kHz	5.6 μ V
	100 mV @ 20 kHz	6.0 μ V
	100 mV @ 100 kHz	5.9 μ V
	100 mV @ 300 kHz	12 μ V
	100 mV @ 1 MHz	75 μ V
	1 V @ 1 kHz	0.44 μ V
	1 V @ 20 kHz	0.38 μ V
	1 V @ 50 kHz	0.65 μ V
	1 V @ 100 kHz	0.92 μ V
	1 V @ 300 kHz	0.18 mV
	1 V @ 500 kHz	0.61 mV
	1 V @ 1 MHz	0.66 mV
	3 V @ 100 kHz	0.35 mV
	10 V @ 10 Hz	0.58 mV
	10 V @ 20 Hz	0.46 mV
	10 V @ 40 Hz	0.39 mV
	10 V @ 1 kHz	0.36 mV
	10 V @ 4 kHz	0.36 mV
	10 V @ 8 kHz	0.36 mV
	10 V @ 10 kHz	0.35 mV
	10 V @ 20 kHz	0.36 mV
	10 V @ 50 kHz	0.37 mV
	10 V @ 100 kHz	1.2 mV
	10 V @ 300 kHz	2.8 mV
	10 V @ 500 kHz	8.2 mV
	10 V @ 1 MHz	8.5 mV
	100 V @ 1 kHz	5.6 mV
	100 V @ 20 kHz	9.2 mV
	100 V @ 50 kHz	11 mV
	100 V @ 100 kHz	15 mV
	700 V @ 1 kHz	33 mV
	700 V @ 20 kHz	78 mV



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<u>Instrument Calibrated/ Measurement Parameter</u>	<u>Range</u>	<u>Best measurement capability expressed as an uncertainty (\pm) *</u>	
DC/LF Measure			
17. AC Voltage continue	10 mV @ 4 MHz	59 μ V	
	100 mV @ 4 MHz	0.54 mV	
	100 mV @ 8 MHz	1.1 mV	
	100 mV @ 10 MHz	1.3 mV	
	1V @ 4 MHz	5.2 mV	
	1V @ 8 MHz	10 mV	
	1V @ 10 MHz	4.3 mV	
	3V @ 2 MHz	16 mV	
	3V @ 4 MHz	16 mV	
	3V @ 8 MHz	30 mV	
	3V @ 10 MHz	39 mV	
	18. AC Current	10 μ A @ 1 kHz	5.3 nA
		100 μ A @ 1 kHz	13 nA
1 mA @ 1 kHz		0.13 μ A	
10 mA @ 1 kHz		1.3 μ A	
100 mA @ 1 kHz		13 μ A	
1A @ 1 kHz		0.24 mA	
19. Frequency	1 Hz	60 μ Hz	
	10 MHz	70 Hz	

Signatories:

- | | |
|-------------------|--------------------------|
| 1. Lau Chee Keong | I/C No. : 741028-07-5791 |
| 2. Yong En Haur | I/C No. : 780510-10-5225 |



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FIELD OF CALIBRATION : DIMENSIONAL

SCOPE OF ACCREDITATION:

<u>Instrument Calibrated/ Measurement Parameter</u>	<u>Range</u>	<u>Best measurement capability expressed as an uncertainty (±) *</u>
Plain Plug Gages	0.5 mm to 12 mm	0.22 μm
Thread plug gages Pitch Diameter (metric threads, 0.2 – 6 mm pitch)	1.0 mm to 15 mm	1.3 μm

Signatories:

- | | |
|------------------|--------------------------|
| 1. Beh Bak Heng | I/C No. : 570918-08-6261 |
| 2. Khoo Teng Kok | I/C No. : 740203-07-5453 |

