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LABORATORY LOCATION:
(PERMANENT LABORATORY)

**TEKTRONIX MALAYSIA CALIBRATION
LABORATORY**
TEKTRONIX INSTRUMENTS MALAYSIA SDN. BHD.
UNIT 1-15-6 SUNTECH @ PENANG CYBERCITY
LINTANG MAYANG PASIR 3
11950 BAYAN BARU
PENANG, MALAYSIA

FIELD OF CALIBRATION: ELECTRICAL

This laboratory has demonstrated its technical competence to operate in accordance with MS ISO/IEC 17025:2017 (ISO/IEC 17025:2017).

This laboratory's fulfillment of the requirements of ISO/IEC 17025 means the laboratory meets both the technical competence requirements and management system requirements that are necessary for it to consistently deliver technically valid test results and calibrations. The management system requirements in ISO/IEC 17025 are written in language relevant to laboratory operations and operate generally in accordance with the principles of ISO 9001 (see Joint ISO-ILAC-IAF Communiqué dated April 2017).

* The uncertainty covered by the CMC is expressed as the expanded uncertainty corresponding to a coverage probability of approximately 95 % and have a coverage factor of $k=2$ unless stated otherwise.

SCOPE OF CALIBRATION: ELECTRICAL

PERMANENT LABORATORY AND SITE CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(\pm)*	Remarks
DC Voltage Source	0 mV to 100 mV 100 mV to 1 V 1 V to 10 V 10 V to 100 V 100 V to 1000 V	5.5 μ V/V + 0.78 μ V 4.7 μ V/V + 0.78 μ V 4.7 μ V/V + 1.6 μ V 6.2 μ V/V + 24 μ V 6.2 μ V/V + 78 μ V + 9.3x10 ⁻⁶ * Vin ² μ V/V	Measurement using Agilent 3458A
	0 mv to 200 mV 200 mV to 2 V 2 V to 20 V 20 V to 200 V 200 V to 1000 V	4.5 μ V/V + 0.1 μ V 3 μ V/V + 0.4 μ V 3 μ V/V + 4 μ V 4.5 μ V/V + 40 μ V 4.5 μ V/V + 1 mV	Measurement using Fluke 8508A
DC Current Source	0 nA to 100 nA 0.1 μ A to 1 μ A 1 μ A to 10 μ A 10 μ A to 100 μ A 100 μ A to 1 mA 1 mA to 10 mA 10 mA to 100 mA 100 mA to 1 A	27 μ A/A + 31 pA 20 μ A/A + 31 pA 20 μ A/A + 78 pA 20 μ A/A + 0.62 nA 20 μ A/A + 3.9 nA 20 μ A/A + 39 nA 31 μ A/A + 0.39 μ A 90 μ A/A + 7.8 μ A	Measurement using Agilent 3458A

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SCOPE OF CALIBRATION: ELECTRICAL**PERMANENT LABORATORY AND SITE CATEGORY I**

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(\pm)*	Remarks
DC Current Source (continue)	0 μ A to 200 μ A 200 μ A to 2mA 2 mA to 20 mA 20 mA to 200 mA 200 mA to 2 A 2 A to 20 A	12 μ A/A + 0.42 nA 12 μ A/A + 0.42 nA 13 μ A/A + 42 nA 36 μ A/A + 42 nA 0.17 mA/A + 0.17 μ A 0.38 mA/A + 0.42 mA	Measurement using Fluke 8508A
Resistance Source	0 Ω to 10 Ω 10 Ω o 100 Ω 100 Ω to 1 k Ω 1 k Ω to 10 k Ω 10 k Ω to 100 k Ω 100 k Ω to 1 M Ω 1 M Ω to 10 M Ω 10 M Ω to 100 M Ω	14 $\mu\Omega/\Omega$ + 39 $\mu\Omega$ 12 $\mu\Omega/\Omega$ + 0.39 m Ω 10 $\mu\Omega/\Omega$ + 0.39 m Ω 10 $\mu\Omega/\Omega$ + 3.9 m Ω 10 $\mu\Omega/\Omega$ + 39 m Ω 14 $\mu\Omega/\Omega$ +1.6 Ω 41 $\mu\Omega/\Omega$ + 78 Ω 0.39 m Ω/Ω + 0.78 k Ω	Measurement using Agilent 3458A
	0 Ω to 2 Ω 2 Ω to 20 Ω 20 Ω to 200 Ω 200 Ω to 2 k Ω 2 k Ω to 20 k Ω 20 k Ω to 200 k Ω 200 k Ω to 2 M Ω 2 M Ω to 20 M Ω 20 M Ω to 200 M Ω	15 $\mu\Omega/\Omega$ + 4 $\mu\Omega$ 9 $\mu\Omega/\Omega$ + 14 $\mu\Omega$ 7.5 $\mu\Omega/\Omega$ + 50 $\mu\Omega$ 7.5 $\mu\Omega/\Omega$ + 0.5 m Ω 7.5 $\mu\Omega/\Omega$ + 5 m Ω 7.5 $\mu\Omega/\Omega$ + 50 m Ω 8.5 $\mu\Omega/\Omega$ + 1 Ω 15 $\mu\Omega/\Omega$ + 0.1m Ω 60 $\mu\Omega/\Omega$ + 10 k Ω	Measurement using Fluke 8508A
AC Voltage Source	0 V to 1000 V (See Matrix A)	See Matrix A	Measurement using Agilent 3458A
	0 V to 1000 V (See Matrix B)	See Matrix B	Measurement using Fluke 8508A
AC Current Source	0 μ A to 1 A (See Matrix C)	See Matrix C	Measurement using Agilent 3458A
	0 μ A to 1 A (See Matrix D)	See Matrix D	Measurement using Fluke 8508A

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SCOPE OF CALIBRATION: ELECTRICAL**PERMANENT LABORATORY AND SITE CATEGORY I****Matrix A – AC Voltage Source**

Range	Frequency								
	Hz			kHz			MHz		
	10 to 20	20 to 40	40 to 100	0.1 to 20	20 to 50	50 to 100	0.1 to 0.25	0.25 to 0.5	0.5 to 1
0 mV to 10 mV	3.1 + 0.025	1.2 + 0.02	0.47 + 0.02	0.16 + 0.02	1.2 + 0.02	5.5 + 0.028	31 + 0.055	-	-
10 mV to 100 mV	3.1 + 0.016	1.2 + 0.016	0.47 + 0.0078	0.16 + 0.0078	1.2 + 0.031	4.7 + 0.062	16 + 0.39	-	-
100 mV to 1 V	-	1.2 + 0.16	0.47 + 0.078	0.16 + 0.078	1.2 + 0.31	4.7 + 0.62	16 + 3.9	24 + 4.7	39 + 16
1 V to 10 V	-	1.2 + 1.6	0.47 + 0.78	0.16 + 0.78	1.2 + 3.1	4.7 + 6.2	16 + 39	24 + 47	39 + 160
10 V to 100 V	-	1.2 + 1.6	0.47 + 7.8	0.24 + 7.8	1.2 + 31	4.7 + 62	16 + 390	-	-
100 V to 1000 V	-	-	0.63 + 160	0.47 + 160	1.2 + 310	4.7 + 1600	-	-	-

The expanded uncertainties given in this table are expressed in mV/V + mV

Matrix B – AC Voltage Source

Range	Frequency							
	Hz		kHz				MHz	
	10 to 40	40 to 100	0.1 to 2	2 to 10	10 to 30	30 to 100	100 to 300	0.3 to 1
0 to 200 mV	0.13 + 0.004	0.11 + 0.004	0.11 + 0.002	0.11 + 0.004	0.31 + 0.008	0.71 + 0.02	-	-
200 mV to 2 V	0.11 + 0.02	0.085 + 0.02	0.065 + 0.02	0.085 + 0.02	0.21 + 0.04	0.51 + 0.2	-	-
2 V to 20 V	0.11 + 0.2	0.085 + 0.2	0.065 + 0.2	0.085 + 0.2	0.21 + 0.4	0.51 + 2	3 + 20	10 + 200
20 V to 200 V	0.11 + 2	0.085 + 2	0.065 + 2	0.085 + 2	0.21 + 4	0.51 + 20	-	-

Range	Frequency	
	kHz	
	0.04 to 10	10 to 30
200 V to 300 V	0.095 + 40	
300 to 1000 V	$[0.095 + (0.0000004 \cdot (V_{in} - 300)^2)] + 40$	$[0.21 + (0.0000024 \cdot (V_{in} - 300)^2)] + 80$

The expanded uncertainties given in this table are expressed in mV/V + mV

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SCOPE OF CALIBRATION: ELECTRICAL**PERMANENT LABORATORY AND SITE CATEGORY I****Matrix C – AC Current Source**

Range	Frequency				
	Hz			kHz	
	10 to 20	20 to 45	45 to 100	0.1 to 5	5 to 20
0 μ A to 100 μ A	3.1 + 0.024	1.2 + 0.024	0.47 + 0.024	0.47 + 0.024	-
100 μ A to 1 mA	3.1 + 0.16	1.2 + 0.16	0.47 + 0.16	0.24 + 0.16	0.47 + 0.16
1 mA to 10 mA	3.1 + 1.6	1.2 + 1.6	0.47 + 1.6	0.24 + 1.6	0.47 + 1.6
10 mA to 100 mA	3.1 + 16	1.2 + 16	0.47 + 16	0.24 + 16	0.47 + 16
100 mA to 1 A	3.1 + 160	1.3 + 160	0.63 + 160	0.78 + 160	2.4 + 160

Matrix D – AC Current Source

Range	Frequency
	kHz
	0.01 to 10
0 μ A to 200 μ A	0.48 + 0.02
200 μ A to 2 mA	0.28 + 0.2
2 mA to 20 mA	0.28 + 2
20 mA to 200 mA	0.25 + 20

Range	Frequency	
	kHz	
	0.01 to 2	2 to 10
200 mA to 2 A	0.6 + 0.2	0.71 + 0.2
2 A to 20 A	0.8 + 2	2.5 + 2

The expanded uncertainties given in this table are expressed in mA/A + μ A

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SCOPE OF CALIBRATION: ELECTRICAL**PERMANENT LABORATORY AND SITE CATEGORY I**

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(\pm)*	Remarks
DC Voltage Measurement	0 mV to 220 mV 220 mV to 2.2 V 2.2 V to 11 V 11 V to 22 V 22 V to 220 V 220 V to 1100 V	7.5 μ V/V + 0.4 μ V 5 μ V/V + 0.7 μ V 3.5 μ V/V + 2.5 μ V 3.5 μ V/V + 4 μ V 5 μ V/V + 40 μ V 6.5 μ V/V + 0.4 mV	Measurement using Fluke 5720A
DC Current Measurement	0 μ A to 220 μ A 220 μ A to 2.2 mA 2.2 mA to 22 mA 22 mA to 100 mA 100 mA to 220 mA 220 mA to 1 A 1 A to 2.2 A	40 μ A/A + 6 nA 35 μ A/A + 7 nA 35 μ A/A + 40 nA 45 μ A/A + 0.7 μ A (45 μ A/A + 0.2 mA/A * I ²) + 0.7 μ A 80 μ A/A + 12 μ A (80 μ A/A + 10 μ A/A * I ²) + 12 μ A	Measurement using Fluke 5720A
	2.2 A to 11 A	0.36 mA/A + 0.48 mA	Measurement using Fluke 5725A
Resistance Measurement (Specific Value)	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 1 M Ω 1.9 M Ω 10 M Ω 19 M Ω 100 M Ω	95 μ Ω / Ω 95 μ Ω / Ω 23 μ Ω / Ω 23 μ Ω / Ω 10 μ Ω / Ω 10 μ Ω / Ω 8.5 μ Ω / Ω 8.5 μ Ω / Ω 8.5 μ Ω / Ω 8.5 μ Ω / Ω 11 μ Ω / Ω 11 μ Ω / Ω 20 μ Ω / Ω 21 μ Ω / Ω 40 μ Ω / Ω 47 μ Ω / Ω 0.1 m Ω / Ω	Measurement using Fluke 5720A
AC Voltage Measurement	2.2 mV to 220 V (See Matrix E)	See Matrix E	Measurement using Fluke 5720A
	220 V to 1100 V (See Matrix E)	See Matrix E	Measurement using Fluke 5725A

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Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(\pm)*	Remarks
AC Current Measurement	0 μ A to 2.2 A (see Matrix F)	see Matrix F	Measurement using Fluke 5720A
	2.2 A to 11 A (see Matrix F)	see Matrix F	Measurement using Fluke 5725A

Matrix E – AC Voltage Measurement

Range	Frequency							
	Hz		kHz			MHz		
	10 to 20	20 to 40	0.04 to 20	20 to 50	50 to 100	0.1 to 0.3	0.3 to 0.5	0.5 to 1
2.2 mV to 22 mV	0.24 + 0.004	0.09 + 0.004	0.08 + 0.004	0.2 + 0.004	0.5 + 0.005	1.1 + 0.01	-	-
22mV to 220 mV	0.24 + 0.012	0.09 + 0.007	0.08 + 0.007	0.2 + 0.007	0.46 + 0.017	0.9 + 0.02	-	-
220 mV to 2.2 V	0.24 + 0.04	0.09 + 0.015	0.045 + 0.008	0.075 + 0.01	0.11 + 0.03	0.42 + 0.08	1 + 0.2	1.7 + 0.3
2.2 V to 22 V	0.24 + 0.4	0.09 + 0.15	0.045 + 0.05	0.075 + 0.1	0.1 + 0.2	0.28 + 0.6	1 + 2	1.5 + 3.2
22 V to 220 V	0.24 + 4	0.09 + 1.5	0.052 + 0.6	0.08 + 1	0.15 + 2.5	-	-	-

Range	Frequency				
	kHz				
	0.04 to 1	1 to 20	20 to 30	30 to 50	50 to 100
220 V to 750 V	-	-	-	0.6 + 11	2.3 + 45
750 V to 1100 V	0.09 + 4	0.17 + 6	0.6 + 11	-	-

The expanded uncertainties given in this table are expressed in mV/V + mV

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SCOPE OF CALIBRATION: ELECTRICAL**PERMANENT LABORATORY AND SITE CATEGORY I****Matrix F – AC Current Measurement**

Range	Frequency				
	Hz		kHz		
	10 to 20	20 to 40	0.04 to 1	1 to 5	5 to 10
0 μ A to 220 μ A	0.25 + 0.016	0.16 + 0.01	0.12 + 0.008	0.28 + 0.012	1.1 + 0.065
220 μ A to 2.2 mA	0.25 + 0.04	0.16 + 0.035	0.12 + 0.035	0.2 + 0.11	1.1 + 0.65
2.2 mA to 22 mA	0.25 + 0.4	0.16 + 0.35	0.12 + 0.35	0.2 + 0.55	1.1 + 5
22 mA to 220 mA	0.25 + 4	0.16 + 3.5	0.12 + 2.5	0.2 + 3.5	1.1 + 10

Range	Frequency		
	kHz		
	0.02 to 1	1 to 5	5 to 10
220 mA to 2.2 A	0.26 + 35	0.45 + 80	7 + 160

Range	Frequency		
	kHz		
	0.04 to 1	1 to 5	5 to 10
2.2 A to 11 A	0.46 + 170	0.95 + 380	3.6 + 750

The expanded uncertainties given in this table are expressed in mA/A + μ A

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SCOPE OF CALIBRATION: ELECTRICAL**PERMANENT LABORATORY AND SITE CATEGORY I**

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(\pm)*	Remarks
Multimeter/Indicating Meter			
Frequency	10Hz to 100Hz 100Hz to 1000Hz 1kHz to 10kHz 10kHz to 100kHz 100kHz to 1 MHz	2.2 μ Hz/Hz + 8.5 μ Hz 2.0 μ Hz/Hz + 20 μ Hz 2.0 μ Hz/Hz + 96 μ Hz 2.0 μ Hz/Hz + 0.96mHz 2.1 μ Hz/Hz + 19mHz	
Capacitance	0.4nF to 1.0999nF 1.1nF to 3.2999nF 3.3nF to 10.9999nF 11nF to 32.9999nF 33nF to 109.999nF 110nF to 329.999nF 330nF to 1.0999 μ F 1.1 μ F to 3.2999 μ F 3.3 μ F to 10.9999 μ F 11 μ F to 32.9999 μ F 33 μ F to 109.999 μ F 110 μ F to 329.999 μ F 0.33mF to 1.0999mF 1.1mF to 3.2999mF 3.3mF to 10.9999mF 11mF to 32.9999mF 33mF to 110mF	4.0mF/F + 8.0pF 3.9mF/F + 9.3pF 2.2mF/F + 8.2pF 1.3mF/F + 58pF 2.0mF/F + 27pF 1.3mF/F + 0.51nF 2.0mF/F + 0.9nF 1.8mF/F + 5.6nF 2.0mF/F + 9.0nF 2.9mF/F + 53nF 3.5mF/F + 98nF 3.3mF/F + 0.49 μ F 3.5mF/F + 0.98 μ F 3.4mF/F + 4.9 μ F 3.5mF/F + 10 μ F 6.1mF/F + 37 μ F 9.2mF/F + 72 μ F	Measurement using Fluke 5522A
Resistance	0 Ω to 10.9999 Ω 11 Ω to 32.9999 Ω 33 Ω to 109.9999 Ω 110 Ω to 329.9999 Ω 330 Ω to 1.09999k Ω 1.1k Ω to 3.29999k Ω 3.3k Ω to 10.9999k Ω 11k Ω to 32.9999k Ω 33k Ω to 109.999k Ω 110k Ω to 329.9999k Ω 330k Ω to 1.09999M Ω 1.1M Ω to 3.29999M Ω 3.3M Ω to 10.9999M Ω 11M Ω to 32.9999M Ω 33M Ω to 109.999M Ω 110M Ω to 329.999M Ω 330M Ω to 1100M Ω	28 μ Ω / Ω + 0.83m Ω 28 μ Ω / Ω + 1.2m Ω 24 μ Ω / Ω + 1.1m Ω 23 μ Ω / Ω + 1.7m Ω 22 μ Ω / Ω + 2.0m Ω 23 μ Ω / Ω + 17m Ω 24 μ Ω / Ω + 12m Ω 23 μ Ω / Ω + 0.17 Ω 22 μ Ω / Ω + 0.20 Ω 29 μ Ω / Ω + 5.3 Ω 26 μ Ω / Ω + 5.8 Ω 50 μ Ω / Ω + 40 Ω 0.10m Ω / Ω + 72 Ω 0.21m Ω / Ω + 2.2k Ω 0.42m Ω / Ω + 1.6k Ω 2.5m Ω / Ω + 72k Ω 13m Ω / Ω	

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SCOPE OF CALIBRATION: ELECTRICAL**PERMANENT LABORATORY AND SITE CATEGORY I**

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(\pm)*	Remarks
Multimeter/Indicating Meter (<i>continue</i>)	<u>33V to 329.999V</u> 45Hz to 1kHz	0.16mV/V + 2.0mV	Measurement using Fluke 5522A
AC Voltage	<u>330V to 1020V</u> 45Hz to 1kHz	0.24mV/V + 11mV	
	1kHz to 5kHz	0.21mV/V + 8.6mV	
	5kHz to 10kHz	0.24mV/V + 11mV	

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Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(\pm)*	Remarks
Clamp Meter DC Current	3.3A to 10.999A 11A to 29.999A 30A to 109.999A 110A to 205A 205A to 549.995A 550A to 1025A	0.34mA/A + 60mA 0.75mA/A + 55mA 1.7mA/A + 41mA 2.5mA/A + 80mA 4.0mA/A + 0.44A 4.4mA/A + 0.20A	Measurement using Fluke 5522A and Fluke 5500A/Coil 50 Turn Coil
AC Current	<u>3.3A to 10.999A</u> 45Hz to 1kHz <u>11A to 29.999A</u> 45Hz to 1kHz <u>30A to 109.999A</u> 45Hz to 1kHz <u>110A to 205A</u> 45Hz to 1kHz <u>205A to 549.995A</u> 45Hz to 65Hz <u>550A to 1025A</u> 45Hz to 65Hz	0.34mA/A+60mA 0.88mA/A+54mA 1.9mA/A+52mA 1.9mA/A+47mA 4.7mA/A+0.78A 4.8mA/A+0.69A	Measurement using Fluke 5522A and Fluke 5500A/Coil 50 Turn Coil

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Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(\pm)*	Remarks
Multimeter/Indicating Meter			
DC Voltage	0mv to 329.9999mV 329.9999mV to 3.299999V 3.299999V to 32.99999V 32.99999V to 329.9999V 329.9999V to 1020.00V	16uV/V+0.78uV 8.6uV/V+1.6uV 9.3uV/V+16uV 14uV/V+0.12mV 14uV/V+1.2mV	Measurement using Fluke 5522A
DC Current	0uA to 329.9999uA 329.9999uA to 3.299999mA 3.299999mA to 32.9999mA 32.9999mA to 329.999mA 329.999mA to 1.0999A 1.1A to 2.99999A 2.99999A to 10.9999A 11A to 20.5A	0.12mA/A+16nA 78uA/A+39nA 78uA/A+0.20uA 78uA/A+2.0uA 0.16mA/A+31uA 0.3mA/A+31uA 0.39mA/A+0.39mA 0.78mA/A+0.59mA	

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SCOPE OF CALIBRATION: TEMPERATURE**PERMANENT LABORATORY AND SITE CATEGORY I**

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(\pm)*	Remarks
Thermocouple K Type	-200°C to -100°C -100°C to -25°C -25°C to 120°C 120°C to 1000°C 1000°C to 1372°C	0.29°C 0.19°C 0.18°C 0.24°C 0.35°C	By electrical simulation using Fluke 5522A
J Type	-210°C to -100°C -100°C to -30°C -30°C to 150°C 150°C to 760°C 760°C to 1200°C	0.29°C 0.23°C 0.22°C 0.23°C 0.26°C	

Signatories:

1. Ching Gin Kong
2. Tan Chin Seong