LABORATORY LOCATION:
(PERMANENT LABORATORY)

INTEGRAJAYA CALIBRATION TECHNOLOGIES SDN. BHD.
NO. 11, LINTANG BAYAN LEPAS 6,
TAMAN PERINDUSTRIAN BAYAN LEPAS,
FASA 4,11900 BAYAN LEPAS,
PULAU PINANG, MALAYSIA

FIELD(S) OF CALIBRATION: **ELECTRICAL,TEMPERATURE**

This laboratory has demonstrated its technical competence to operate in accordance with MS ISO/IEC 17025:2005 (ISO/IEC 17025:2005).

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

*** The CMC is expressed as ± (of indication in µV/V + floor value in µV)**

SCOPE OF CALIBRATION: ELECTRICAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
1. Indicating instrument			
DC VOLTAGE	0 µV to 200 mV 0.22 V 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	9.1 µV/V + 0.68 µV 7.9 µV/V + 1.1 µV 7.9 µV/V + 4.0 µV 7.9 µV/V + 7.4 µV 9.1 µV/V + 91 µV 10 µV/V + 0.57 mV	Generation using calibrator model Fluke 5700A
	1000 V to 10,000V	11 mV/V + 3.9 V	Compare with Vitrek 4670B Precision High Voltage Meter

SCOPE OF CALIBRATION: ELECTRICAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
1. Indicating instrument			
DC CURRENT	0 to 220 µA 0.22 mA to 2.2 mA 2.2 mA to 22 mA 22 mA to 220 mA 0.22 A to 2.2 A	57 µA/A + 9.1 nA 51 µA/A + 9.1 nA 57 µA/A + 91 nA 68 µA/A + 0.91 µA 0.09 mA/A + 28 µA	Generation using calibrator model Fluke 5700A
	0.32 A to 3.2 A 3.2 A to 10.5 A	0.60 mA/A + 0.44 mA 0.60 mA/A + 1.2 mA	Generation using calibrator model Wavetek 9100
	3.2 A to 32 A 32 A to 105 A 105 A to 200 A	1.3 mA/A + 50 mA 2.2 mA/A + 25 mA 2.3 mA/A + 29 mA	Generation using calibrator model Wavetek 9100 & 10 turn coil
	16 A to 160 A 160 A to 525 A 525 A to 1000 A	2.2 mA/A + 29 mA 2.3 mA/A + 23 mA 2.3 mA/A + 0.1 A	Generation using calibrator model Wavetek 9100 & 50 turn coil
AC VOLTAGE	0.22 mV to 220 V 220 V to 1050 V	(See Matrix A1) (See Matrix A2)	Generation using calibrator model Fluke 5700A & Wavetek 9100

SCOPE OF CALIBRATION: ELECTRICAL

<table>
<tr><th>Instrument Calibrated/ Measurement Parameter</th><th>Range</th><th>Calibration and Measurement Capability Expressed as an Uncertainty(±)*</th><th>Remarks</th></tr>
<tr><td>AC CURRENT</td><td>0 µA to 10.5 A</td><td>(See Matrix B)</td><td>Generation using calibrator model Wavetek 9100</td></tr>
<tr><td></td><td>
<table>
<tr><th rowspan="2">Range</th><th colspan="5">FREQUENCY</th></tr>
<tr><th>(10 to 20) Hz</th><th>(20 to 40) Hz</th><th>(0.04 to 1) kHz</th><th>(1 to 5) kHz</th><th>(5 to 10) kHz</th></tr>
<tr><td>2.2 µA to 220 µA</td><td>0.79 + 0.028</td><td>0.40 + 0.023</td><td>0.16 + 0.018</td><td>0.68 + 0.045</td><td>1.8 + 0.091</td></tr>
<tr><td>0.22 mA to 2.2 mA</td><td>0.79 + 0.045</td><td>0.40 + 0.04</td><td>0.16 + 0.04</td><td>0.68 + 0.45</td><td>1.8 + 0.91</td></tr>
<tr><td>2.2 mA to 22 mA</td><td>0.79 + 0.45</td><td>0.40 + 0.40</td><td>0.16 + 0.40</td><td>0.68 + 4.5</td><td>1.8 + 9.1</td></tr>
<tr><td>22 mA to 220 mA</td><td>0.79 + 4.5</td><td>0.40 + 4.0</td><td>0.16 + 4.0</td><td>0.68 + 45</td><td>1.8 + 91</td></tr>
<tr><td>0.22 A to 2.2 A</td><td>0.74 + 40</td><td>0.74 + 40</td><td>0.74 + 40</td><td>0.85 + 91</td><td>9.6 + 180</td></tr>
<tr><td colspan="6">The expanded uncertainties given in this table are expressed in mA/A + µA</td></tr>
</table>
</td><td>Generation using calibrator model Fluke 5700A</td></tr>
<tr><td></td><td>
<table>
<tr><th rowspan="2">Range</th><th colspan="2">FREQUENCY</th></tr>
<tr><th>(10 to 100) Hz</th><th>(100 to 440) Hz</th></tr>
<tr><td>3.2 A to 32 A</td><td>2.2 mA/A + 48 mA</td><td>8.5 mA/A + 52 mA</td></tr>
<tr><td>32 A to 200 A</td><td>3.2 mA/A + 96 mA</td><td>7.9 mA/A + 280 mA</td></tr>
<tr><td>16 A to 160 A</td><td>3.1 mA/A + 43 mA</td><td></td></tr>
<tr><td>160 A to 1000 A</td><td>3.2 mA/A + 440 mA</td><td></td></tr>
</table>
</td><td>Generation using calibrator model Wavetek 9100 & 10/50 turn coil</td></tr>
<tr><td>**DC POWER</td><td>0.1024 mV to 10.5 kW</td><td>(See Matrix C)</td><td>Generation using calibrator model Wavetek 9100</td></tr>
<tr><td>**AC POWER</td><td>0.1024 mW to 7.7875 kW
@ 10 Hz to 3 kHz</td><td>(See Matrix D)
Power Factor = 1</td><td>Generation using calibrator model Wavetek 9100</td></tr>
</table>

SCOPE OF CALIBRATION: ELECTRICAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
1. Indicating instrument			
DC RESISTANCE (Specific Value)	1 mΩ 10 mΩ 100 mΩ 1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ	0.87 uΩ 11 uΩ 0.11 mΩ 1.1 mΩ 3.9 mΩ 32 mΩ 0.32 Ω 3.2 Ω 32 Ω	Generation using Standard Resistor model Agilent 42030A (4-Terminal Resistance)
	1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 kΩ 1.9 k Ω 10 kΩ 19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	0.11 mΩ 0.20 mΩ 0.32 mΩ 0.58 mΩ 1.9 mΩ 3.7 mΩ 15 mΩ 28 mΩ 0.14 Ω 0.26 Ω 1.6 Ω 3.0 Ω 23 Ω 45 Ω 0.45 kΩ 1 kΩ 12 kΩ	Generation using calibrator model Fluke 5700A
DC RESISTANCE	0 Ω to 40 Ω 40 Ω to 400 Ω 400 Ω to 4 kΩ 4 kΩ to 40 kΩ 40 kΩ to 400 kΩ 400 kΩ to 4 MΩ 4 MΩ to 40 MΩ 40 MΩ to 400 MΩ	0.56 mΩ/Ω + 23 mΩ 0.17 mΩ/Ω + 25 mΩ 0.17 mΩ/Ω + 0.1 Ω 0.17 mΩ/Ω + 1 Ω 0.20 mΩ/Ω + 12 Ω 0.22 mΩ/Ω + 0.14 kΩ 0.56 mΩ/Ω + 2.4 kΩ 0.64 mΩ/Ω + 64 kΩ	Generation using calibrator model Wavetek 9100

SCOPE OF CALIBRATION: ELECTRICAL

1. Indicating instrument

DC RESISTANCE AT HIGH VOLTAGE RANGE (25V to 5KV)

Decade X1	1kΩ	10kΩ	100kΩ	1MΩ	10MΩ	100MΩ	1GΩ
1	0.23 Ω	2.3 Ω	23 Ω	0.8 kΩ	9.8 kΩ	0.17 MΩ	4.1 MΩ
2	0.46 Ω	4.6 Ω	46 Ω	1.6 kΩ	59 kΩ	0.33 MΩ	9.9 MΩ
3	0.69 Ω	6.9 Ω	69 Ω	6.2 kΩ	62 kΩ	0.48 MΩ	14 MΩ
4	0.91 Ω	9.1 Ω	91 Ω	6.5 kΩ	65 kΩ	0.64 MΩ	17 MΩ
5	1.2 Ω	12 Ω	0.12 kΩ	7.0 kΩ	70 kΩ	0.80 MΩ	21 MΩ
6	1.4 Ω	14 Ω	0.14 kΩ	7.4 kΩ	74 kΩ	1.0 MΩ	25 MΩ
7	1.6 Ω	16 Ω	0.16 kΩ	8.0 kΩ	80 kΩ	1.2 MΩ	29 MΩ
8	1.9 Ω	19 Ω	0.19 kΩ	8.5 kΩ	86 kΩ	1.3 MΩ	33 MΩ
9	2.1 Ω	21 Ω	0.21 kΩ	9.2 kΩ	92 kΩ	1.5 MΩ	37 MΩ
10	2.3 Ω	23 Ω	0.24 kΩ	9.8 kΩ	98 kΩ	1.7 MΩ	41 MΩ

Remarks: Generation using Decade Resistance model IET HRRS

AC RESISTANCE (Specific Value)

Range	100 kHz	1 MHz	2 MHz	3 MHz	4 MHz	5 MHz	10 MHz	13 MHz
10 Ω	-	3.8 mΩ	5.6 mΩ	6.5 mΩ	7.5 mΩ	11 mΩ	41 mΩ	61 mΩ
100 Ω	-	39 mΩ	47 mΩ	56 mΩ	56 mΩ	56 mΩ	0.21 Ω	0.31 Ω
1 kΩ	0.39 Ω	0.39 Ω	0.39 Ω	0.39 Ω	0.47 Ω	0.56 Ω	2.1 Ω	3.1 Ω
10 kΩ	3.2 Ω	3.9 Ω	-	-	-	-	-	-
100 kΩ	39 Ω	39 Ω	-	-	-	-	-	-

Remarks: Generation using Standard Resistor model Agilent 42030A (4-Terminal Resistance Set)

CAPACITANCE

Range	Frequency	
	≤ 350 Hz	0.35 to 1.5 kHz
0.5 nF to 4.0 nF	3.4 mF/F + 17 pF	6.8 mF/F + 34 pF
4 nF to 40 nF	3.4 mF/F + 34 pF	6.8 mF/F + 68 pF
40 nF to 400 nF	3.4 mF/F + 0.18 nF	6.8 mF/F + 0.36 nF
400 nF to 4 µF	4.5 mF/F + 1.8 nF	9.1 mF/F + 3.6 nF
4 µF to 40 µF	5.7 mF/F + 18 nF	11 mF/F + 36 nF
40 µF to 400 µF	5.7 mF/F + 0.18 µF	11 mF/F + 0.36 µF
400 µF to 4 mF	5.7 mF/F + 1.8 µF	11 mF/F + 3.6 µF
4 mF to 40 mF	11 mF/F + 68 µF	23 mF/F + 0.14 mF

Remarks: Generation using calibrator model Wavetek 9100

SCOPE OF CALIBRATION: ELECTRICAL

<table>
<tr><th>Instrument Calibrated/ Measurement Parameter</th><th>Range</th><th>Calibration and Measurement Capability Expressed as an Uncertainty (±)*</th><th>Remarks</th></tr>
<tr><td colspan="4">1. Indicating instrument</td></tr>
<tr><td>CAPACITANCE
(Specific Value)</td><td colspan="2"><table>
<tr><th>Range</th><th>1 pF</th><th>10 pF</th><th>100 pF</th><th>1000 pF</th><th>10 nF</th><th>100 nF</th><th>1 uF</th></tr>
<tr><td>120 Hz</td><td>-</td><td>-</td><td>-</td><td>-</td><td>1.2 pF</td><td>12 pF</td><td>0.13 nF</td></tr>
<tr><td>1 kHz</td><td>0.69 fF</td><td>6.9 fF</td><td>0.069 pF</td><td>0.69 pF</td><td>1.2 pF</td><td>12 pF</td><td>0.12 nF</td></tr>
<tr><td>10 kHz</td><td>0.69 fF</td><td>6.9 fF</td><td>0.069 pF</td><td>0.69 pF</td><td>1.2 pF</td><td>12 pF</td><td>0.12 nF</td></tr>
<tr><td>100 kHz</td><td>0.69 fF</td><td>6.9 fF</td><td>0.069 pF</td><td>0.69 pF</td><td>1.2 pF</td><td>12 pF</td><td>0.12 nF</td></tr>
<tr><td>1 MHz</td><td>0.69 fF</td><td>6.9 fF</td><td>0.069 pF</td><td>0.69 pF</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>2 MHz</td><td>0.72 fF</td><td>6.9 fF</td><td>0.069 pF</td><td>0.70 pF</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>3 MHz</td><td>0.80 fF</td><td>6.9 fF</td><td>0.069 pF</td><td>0.74 pF</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>4 MHz</td><td>0.93 fF</td><td>6.9 fF</td><td>0.069 pF</td><td>0.81 pF</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>5 MHz</td><td>1.2 fF</td><td>6.9 fF</td><td>0.070 pF</td><td>0.92 pF</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>10 MHz</td><td>2.6 fF</td><td>6.9 fF</td><td>0.076 pF</td><td>2.1 pF</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>13 MHz</td><td>3.8 fF</td><td>7.0 fF</td><td>0.084 pF</td><td>2.9 pF</td><td>-</td><td>-</td><td>-</td></tr>
</table></td><td>Generation using Standard Capacitor model Agilent 16380A & 16380C (4-Terminal Capacitor Set)</td></tr>
<tr><td>INDUCTANCE</td><td>1 kHz
1mH to 900 mH</td><td>23 mH/H + 0.57 µH</td><td>Generation using calibrator model IET LS-400A</td></tr>
<tr><td>INDUCTANCE
(Specific Value)</td><td>100 Hz, 120 Hz, 1 kHz,
10 kHz, 100 kHz
100 µH
1 mH
10 mH
100 mH
1 H</td><td>0.57 µH
2.3 µH
23 µH
0.23 µH
2.3 mH</td><td>Generation using calibrator model General Radio 1482</td></tr>
</table>

SCOPE OF CALIBRATION: ELECTRICAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty (±)*	Remarks
FREQUENCY	0.1 Hz to 1 Hz 1 Hz to 100 Hz 100 Hz to 1 kHz 1 kHz to 10 kHz 10 kHz to 100 kHz 100 kHz to 1 MHz 1 MHz to 10 MHz 10 MHz to 100 MHz 100 MHz to 1 GHz	9.8 nHz/Hz + 0.12 μHz 62 nHz/Hz + 2.2 μHz 81 nHz/Hz + 4.5 μHz 83 nHz/Hz + 26 μHz 83 nHz/Hz + 0.26 mHz 81 nHz/Hz + 4.4 mHz 81 nHz/Hz + 45 mHz 83 nHz/Hz + 0.23 Hz 85 nHz/Hz + 0.03 Hz	Using 10 MHz Reference model Fluke PM6680B
	0.1 Hz to 100 Hz 0.1 kHz to 100 kHz 0.1 MHz to 100 MHz 0.1 GHz to 9 GHz	1.2 uHz/Hz + 0.22 uHz 1.2 uHz/Hz + 4.1 nHz 34 nHz/Hz + 57 uHz 34 nHz/Hz + 7.2 uHz	Generation using Signal Generator model Agilent 33250A, E8663B & SRS FS725 Rubidium Standard (Reference)
2. Oscilloscope			
a) BANDWIDTH	100 mHz to 100 MHz 100.01 MHz to 550 MHz 550.01 MHz to 1.1 GHz	22 mHz/Hz 34 mHz/Hz 43 mHz/Hz	Generation using calibrator model Fluke 9500/9510
	1 GHz to 3 GHz 3 GHz to 6 GHz	34 mHz/Hz + 1.2 MHz 48 mHz/Hz + 0.35 MHz	Generation using Calibrator model Fluke 9500B & 9560
b) *TIME BASE	@100 mV to 500 mV 180.19 ps – 450 ps 450 ps – 900 ps 0.9 ns – 9 ns @100 mV to 1 V 9 ns - 100 ns 0.1 µs - 10 µs 10 µs - 100 µs 0.1 ms - 10 ms 10 ms - 100 ms 0.1 s - 10 s 10 s - 55 s	0.38 ns/s + 0.072 ps 0.77 ns/s + 0.079 ps 0.48 ns/s + 1.1 ps 0.063 ns/s + 79 ps 0.060 ns/s + 7.2 ns 0.063 ns/s + 79 ns 0.057 ns/s + 7.9 us 0.063 ns/s + 79 us 0.057 ns/s + 7.9 ms 0.046 ns/s + 57 ms	Generation using calibrator model Fluke 9500B & 9510/9560

SCOPE OF CALIBRATION: ELECTRICAL

<table>
<tr><th>Instrument Calibrated/ Measurement Parameter</th><th>Range</th><th>Calibration and Measurement Capability Expressed as an Uncertainty (±)*</th><th>Remarks</th></tr>
<tr><td colspan="4">2. Oscilloscope</td></tr>
<tr><td>c) AMPLITUDE</td><td colspan="2"><table>
<tr><th rowspan="2">Range</th><th colspan="2">DC Signal (±)</th><th colspan="2">Square Signal (10 Hz to 10 kHz)</th></tr>
<tr><th>Into 50 Ω</th><th>Into 1 MΩ</th><th>Into 50 Ω</th><th>Into 1 MΩ</th></tr>
<tr><td>35 µV to 1 mV</td><td>0.25 mV/V + 26 µV</td><td>0.25 mV/V + 25 µV</td><td>10 mV/V + 1.1 µV</td><td>10 mV/V + 1.1 µV</td></tr>
<tr><td>1 mV to 21 mV</td><td>0.25 mV/V + 26 µV</td><td>0.25 mV/V + 25 µV</td><td>2.4 mV/V + 3.6 µV</td><td>2.5 mV/V + 1 µV</td></tr>
<tr><td>21 mV to 100 mV</td><td>0.25 mV/V + 26 µV</td><td>0.25 mV/V + 25 µV</td><td>0.99 mV/V + 1.7 µV</td><td>0.99 mV/V + 1.8 µV</td></tr>
<tr><td>10 0 mV to 556 mV</td><td>0.25 mV/V + 26 µV</td><td>0.25 mV/V + 45 µV</td><td>0.98 mV/V + 16 µV</td><td>0.98 mV/V + 16 µV</td></tr>
<tr><td>556 mV to 5.5 V</td><td>0.25 mV/V + 26 µV</td><td>0.25 mV/V + 45 µV</td><td>0.44 mV/V + 0.33 mV</td><td>0.47 mV/V + 0.3 mV</td></tr>
<tr><td>5.5 V to 10 V</td><td>-</td><td>0.25 mV/V + 45 µV</td><td>-</td><td>0.47 mV/V + 0.3 mV</td></tr>
<tr><td>10 V to 100 V</td><td>-</td><td>0.25 mV/V + 81 µV</td><td>-</td><td>0.40 mV/V + 35 mV</td></tr>
<tr><td>100 V to 210 V</td><td>-</td><td>0.25 mV/V + 93 µV</td><td>-</td><td>0.40 mV/V + 35 mV</td></tr>
<tr><td>210 V to 222 V</td><td>-</td><td>0.25 mV/V + 93 µV</td><td>-</td><td>-</td></tr>
</table></td><td>Generation using calibrator model Fluke 9500 & 9510/9560</td></tr>
<tr><td colspan="4">3. Source</td></tr>
<tr><td rowspan="2">DC VOLTAGE</td><td>0 mV to 100 mV
0.1 V to 1 V
1 V to 10 V
10 V to 100 V
100 V to 1000 V</td><td>8.8 µV/V + 0.49 µV
8.2 µV / V + 0.44 µV
8.3 µV/V + 0.93 µV
11 µV/V + 77 µV
24 µV/V + 29 µV</td><td>Measurement using Multimeter model Agilent 3458A</td></tr>
<tr><td>1 kV to 10 kV</td><td>0.57 mV/V + 0.57 V</td><td>Measurement using High Voltage Meter model Vallaha 4600</td></tr>
<tr><td rowspan="3">AC VOLTAGE</td><td>0 to 1000 V</td><td>(See Matrix E)</td><td>Measurement using Multimeter model Wavetek 1281</td></tr>
<tr><td>1 kV to 2 kV
@ 20 Hz to 60 Hz</td><td>1.1 mV/V + 2.3 V</td><td>Measurement using High Voltage Meter model Vallaha 4600</td></tr>
<tr><td>2 kV to 15 kV
@ 20 Hz to 60 Hz</td><td>5.7 mV/V + 57 V</td><td>Measurement using High Voltage Meter model Vallaha 4600</td></tr>
</table>

SCOPE OF CALIBRATION: ELECTRICAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty (±)*	Remarks
3. Source			
DC CURRENT	0 nA to 100 nA 0.1 uA to 1 uA 1 uA to 10 uA 10 uA to 100 uA 0.1 mA to 1 mA 1 mA to 10 mA 10 mA to 100 mA 0.1 A to 1 A	40 μA/A + 0.077 nA 29 μA/A + 0.089 nA 29 μA/A + 3.3 nA 29 μA/A + 2.7 nA 29 μA/A + 23 nA 29 μA/A + 0.23 μA 46 μA/A + 2.3 μA 0.13 mA/A + 26 μA	Measurement using Multimeter model Agilent 3458A
	1 A to 10 A 10 A to 20 A 20 A to 30 A	16 μA/A + 0.40 mA 48 μA/A + 0.25 mA 0.57 mA/A + 18 μA	Measurement using Multimeter & Current shunt model Agilent 3458A & 34330A
	30 A to 50 A 50 A to 100 A 100 A to 200 A 200 A to 300 A	46 μA/A + 0.72 mA 60 μA/A + 0.41 mA 71 μA/A + 0.21 mA 71 μA/A + 0.14 mA	Measurement using Multimeter & Current shunt model Agilent 3458A & Guildine 9230/1000
AC CURRENT	0 to 2 A	(See Matrix F)	Measurement using Multimeter model Wavetek 1281
	2 A to 10 A	(See Matrix F)	Measurement using Multimeter & Current Shunt model Wavetek 1281 & Wavetek 4953
DC RESISTANCE	0 to 20 Ω 20 Ω to 200 Ω 0.2 kΩ to 2 kΩ 2 kΩ to 20 kΩ 20 kΩ to 200 kΩ 0.2 MΩ to 2 MΩ 2 MΩ to 20 MΩ 20 MΩ to 200 MΩ 0.2 GΩ to 1GΩ	18 μΩ/Ω + 22 μΩ 13 μΩ/Ω + 65 μΩ 11 μΩ/Ω + 0.63 mΩ 11 μΩ/Ω + 6.3 mΩ 13 μΩ/Ω + 56 mΩ 20 μΩ/Ω + 1.3 Ω 37 μΩ/Ω + 87 Ω 0.35 mΩ/Ω + 10 kΩ 3.5 mΩ/Ω + 0.5 MΩ	Measurement using Multimeter model Wavetek 1281
RF POWER	**Range** / **FREQUENCY**: (100 to 300) kHz; (0.3 to 1) MHz; (0.001 to 2) GHz; (2.0 to 4.2) GHz -30 dBm to 20 dBm (1 μW to 100 mW into 50 Ω): 4.6 %; 3.5 %; 3.3 %; 3.7 %		Measurement using Power Meter & Power Sensor model Agilent EPM441A & 8482A

NO: SAMM 122

SCOPE OF CALIBRATION: ELECTRICAL

<table>
<tr><th>Instrument Calibrated/ Measurement Parameter</th><th>Range</th><th>Calibration and Measurement Capability Expressed as an Uncertainty (±)*</th><th>Remarks</th></tr>
<tr><td colspan="4">3. Source</td></tr>
<tr><td>FREQUENCY</td><td>100 mHz to 1 Hz
1 Hz to 100 Hz
100 Hz to 1 kHz
1 kHz to 10 kHz
10 kHz to 100 kHz
100 kHz to 1 MHz
1 MHz to 10 MHz
10 MHz to 100 MHz
100 MHz to 1 GHz
1 GHz to 2.7 GHz</td><td>83 nHz/Hz + 1.9 nHz
56 nHz/Hz + 2.9 μHz
85 nHz/Hz + 0.26 μHz
84 nHz/Hz + 11 μHz
83 nHz/Hz + 0.23 mHz
83 nHz/Hz + 1.9 mHz
84 nHz/Hz + 11 mHz
83 nHz/Hz + 0.23 Hz
83 nHz/Hz + 1.9 Hz
77 nHz/Hz + 31 Hz</td><td>Measurement using Frequency Counter model Fluke PM6680B</td></tr>
<tr><td>FREQUENCY</td><td>300 MHz – 12.4 GHz</td><td>17 nHz/Hz</td><td>Measurement using Frequency Counter & model Agilent 53132A and SRS FS725 Rubidium Standard (Reference)</td></tr>
<tr><td>**TIMER</td><td>1 s to 100 s
100 s to 400 s</td><td>38 us/s + 30 us
34 us/s + 1.8 ms</td><td>Measurement using DSO7104A Oscilloscope</td></tr>
<tr><td>**CAPACITANCE</td><td colspan="2"><table>
<tr><th>Range</th><th>100 Hz</th><th>1 kHz</th><th>10 kHz</th><th>100 kHz</th></tr>
<tr><td>1 pF to 10 pF</td><td>-</td><td>1.2 + 0.00012</td><td>5.0 + 0.000029</td><td>27 + .0000054</td></tr>
<tr><td>10 pF to 100 pF</td><td>1.9 + 0.00077</td><td>1.1 + 0.0013</td><td>2.0 + 0.00071</td><td>15 + 0.000099</td></tr>
<tr><td>100 pF to 1000 pF</td><td>1.80 + 0.0077</td><td>1.1 + 0.013</td><td>1.9 + 0.0073</td><td>14 + 0.0011</td></tr>
<tr><td>1 nF to 10 nF</td><td>1.8 + 0.077</td><td>1.1 + 0.13</td><td>1.9 + 0.074</td><td>14 + 0.011</td></tr>
<tr><td>10 nF to 100 nF</td><td>2.9 + 0.50</td><td>2.9 + 0.50</td><td>2.7 + 0.53</td><td>16 + 0.094</td></tr>
<tr><td>100 nF to 1000 nF</td><td>3.1 + 4.6</td><td>2.0 + 1.2</td><td>3.3 + 4.4</td><td>19 + 0.79</td></tr>
<tr><td>1 uF to 10 uF</td><td>5.8 + 25</td><td>5.4 + 27</td><td>5.4 + 27</td><td>31 + 4.7</td></tr>
<tr><td>10 uF to 100 uF</td><td>13 + 130</td><td>8.8 + 170</td><td>21 + 700</td><td>-</td></tr>
<tr><td>100 uF to 1000 uF</td><td>73 + 200</td><td>47 + 310</td><td>-</td><td>-</td></tr>
<tr><td>1 mF to 10 mF</td><td>-</td><td>55 + 490000</td><td>-</td><td>-</td></tr>
<tr><td>10 mF to 100 mF</td><td>-</td><td>55 + 490000</td><td>-</td><td>-</td></tr>
</table>The expanded uncertainties given in this table expressed in mF/F + pF</td><td>Measurement using HP 4263A LCR Meter</td></tr>
</table>

Signatories:

1. **Lam Sik Lee**
2. **Mohd Rahimi Bin Samsuddin** (* EOS: Time base only, ** Excluded for EOS)

SCOPE OF CALIBRATION: ELECTRICAL

Matrix A1 - AC Voltage Measurement

Range	FREQUENCY							
	(10 to 20) Hz	(20 to 40) Hz	(0.04 to 20) kHz	(20 to 50) kHz	(50 to 100) kHz	(100 to 300) kHz	(300 to 500) kHz	(0.5 to 1.0) MHz
0.22 mV to 2.2 mV	0.62 + 0.0051	0.24 + 0.0051	0.12 + 0.0051	0.42 + 0.0051	0.96 + 0.0079	1.2 + 0.015	1.9 + 0.028	3.9 + 0.028
2.2 mV to 22 mV	0.62 + 0.0057	0.24 + 0.0057	0.12 + 0.0057	0.42 + 0.0057	0.96 + 0.0079	1.2 + 0.014	1.9 + 0.028	3.9 + 0.028
22 mV to 220 mV	0.62 + 0.015	0.24 + 0.0091	0.12 + 0.0091	0.36 + 0.0091	0.96 + 0.028	1.2 + 0.028	1.9 + 0.040	3.9 + 0.12
0.22 V to 2.2 V	0.57 + 0.091	0.18 + 0.028	0.085 + 0.0068	0.14 + 0.018	0.28 + 0.079	0.49 + 0.15	1.2 + 0.040	2.5 + 0.96
2.2 V to 22 V	0.57 + 0.91	0.18 + 0.28	0.085 + 0.068	0.14 + 0.18	0.28 + 0.040	0.57 + 1.7	1.4 + 4.9	3.1 + 9.6
22 V to 220 V	0.57 + 9.1	0.18 + 2.8	0.091 + 0.91	0.25 + 4.0	0.57 + 9.1	1.7 + 100	5.3 + 100	13 + 220

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

Matrix A2 - AC Voltage Measurement

Range	FREQUENCY					
	(15 to 50) Hz	(0.05 to 1) kHz	(1 to 3) kHz	(3 to 10) kHz	(10 to 20) kHz	(20 to 30) kHz
220 V to 1100 V	0.45 + 18	0.091 + 4.0	-	-	-	-
220 V to 320 V	-	-	0.91 + 22	0.91 + 36	1.4 + 48	1.7 + 73
320 V to 800 V	-	-	0.91 + 71	0.91 + 120	1.4 + 180	1.7 + 240
800 V to 1050 V	-	-	0.90 + 150	0.91 + 240	1.4 + 360	-

Matrix B - AC Current Measurement

Range	Frequency			
	(0.01 to 3) kHz	**(3 to 10) kHz**	**(10 to 20) kHz**	**(20 to 30) kHz**
0 µA to 32 µA	0.79 + 1	1.1 + 2	2.3 + 6.8	2.8 + 10
32 µA to 320 µA	0.79 + 0.35	1.1 + 0.68	2.3 + 2.3	2.8 + 3.4
0.32 mA to 3.2 mA	0.79 + 0.48	1.1 + 0.68	2.3 + 2.3	2.8 + 3.4
3.2 mA to 32 mA	0.79 + 4.7	1.1 + 7.3	2.3 + 15	2.8 + 25
32 mA to 320 mA	0.91 + 36	1.1 + 55	2.3 + 73	2.8 + 110
0.32 A to 3.2 A	1.1 + 570	2.8 + 2900	-	-
3.2 A to 10.5 A	2.3 + 3400	5.7 + 11000	-	-

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

SCOPE OF CALIBRATION: ELECTRICAL

Matrix C - DC Power Measurement

Voltage	Current	DC Power	CMC
320 mV	3.2 mA 32 mA 320 mA 3.2 A 10.5 A	(0.1024 to 1.024) mW (1.024 to 10.24) mW (10.24 to 102.4) mW (0.1024 to 1.024) W (1.024 to 3.36) W	0.041 + 0.56 0.17 + 0.42 0.20 + 4.1 0.70 + 26 0.62 + 430
3.2 V	3.2 mA 32 mA 320 mA 3.2 A 10.5 A	(1.024 to 10.24) mW (10.24 to 102.4) mW (0.1024 to 1.024) W (1.024 to 10.24) W (10.24 to 33.6) W	0.17 + 0.42 0.17 + 4.2 0.20 + 41 0.7 + 260 0.62 + 4200
32 V	3.2 mA 32 mA 320 mA 3.2 A 10.5 A	(10.24 to 102.4) mW (0.1024 to 1.024) W (1.024 to 10.24) W (10.24 to 102.4) W (102.4 to 336.0) W	0.17 + 4.2 0.17 + 42 0.2 + 410 0.7 + 2600 0.19 + 550000
320 V	3.2 mA 32 mA 320 mA 3.2 A 10.5 A	(0.1024 to 1.024) W (1.024 to 10.24) W (10.24 to 102.4) W (0.1024 to 1.024) kW (1.024 to 3.36) kW	0.042 + 560 0.16 + 640 0.2 + 4100 0.7 + 26000 0.62 + 430000
1000 V	3.2 mA 32 mA 320 mA 3.2 A 10.5 A	(0.32 to 3.2) W (3.2 to 32) W (32 to 320) W (0.32 to 3.2) kW (3.2 to 10.5) kW	0.11 + 520 0.11 + 5200 0.13 + 51000 0.62 + 370000 0.66 + 800000

The expanded uncertainties given in this table expressed in mW/W + uW

SCOPE OF CALIBRATION: ELECTRICAL

Matrix D - AC Power Measurement

Voltage	Current	AC Power	(10 to 40) Hz	(40 to 100) Hz	(0.1 to 1) kHz	(1 to 3) kHz
320 mV	3.2 mA	(0.1024 to 1.024) mW	0.97 + 77 nW	0.97 + 77 nW	0.97 + 77 nW	0.97 + 77 nW
	32 mA	(1.024 to 10.24) mW	1.0 + 0.00066	1.0 + 0.00066	1.0 + 0.00066	1.0 + 0.00066
	320 mA	(10.24 to 102.4) mW	1.1 + 0.0064	1.1 + 0.0064	1.1 + 0.0064	1.1 + 0.0064
	3.2 A	(0.1024 to 1.024) W	1.4 + 0.081	1.4 + 0.081	1.4 + 0.081	1.4 + 0.081
	10.5 A	(1.024 to 3.36) W	2.5 + 0.63	2.5 + 0.63	2.5 + 0.63	2.5 + 0.63
3.2 V	3.2 mA	(1.024 to 10.24) mW	0.99 + 0.00065	0.99 + 0.00065	0.99 + 0.00065	0.99 + 0.00065
	32 mA	(10.24 to 102.4) mW	0.99 + 0.0066	0.99 + 0.0066	0.99 + 0.0066	0.99 + 0.0066
	320 mA	(0.1024 to 1.024) W	1.1 + 0.075	1.1 + 0.075	1.1 + 0.075	1.1 + 0.075
	3.2 A	(1.024 to 10.24) W	1.4 + 0.71	1.4 + 0.71	1.4 + 0.71	1.4 + 0.71
	10.5 A	(10.24 to 33.6) W	2.5 + 6.3	2.5 + 6.3	2.5 + 6.3	2.5 + 6.3
32 V	3.2 mA	(10.24 to 102.4) mW	0.98 + 0.0068	0.98 + 0.0068	0.98 + 0.0068	0.98 + 0.0068
	32 mA	(0.1024 to 1.024) W	0.97 + 0.083	0.97 + 0.083	0.97 + 0.083	0.97 + 0.083
	320 mA	(1.024 to 10.24) W	1.1 + 0.67	1.1 + 0.67	1.1 + 0.67	1.1 + 0.67
	3.2 A	(10.24 to 102.4) W	1.4 + 7.4	1.4 + 7.4	1.4 + 7.4	1.4 + 7.4
	10.5 A	(102.4 to 336.0) W	2.5 + 63	2.5 + 63	2.5 + 63	2.5 + 63
105 V	3.2 mA	(0.0336 to 0.336) W	0.83 + 0.08	0.83 + 0.08	0.83 + 0.08	0.83 + 0.08
	32 mA	(0.336 to 3.36) W	0.84 + 0.8	0.84 + 0.8	0.84 + 0.8	0.84 + 0.8
	320 mA	(3.36 to 33.6) W	0.94 + 7.7	0.94 + 7.7	0.94 + 7.7	0.94 + 7.7
	3.2 A	(0.0336 to 0.336) kW	1.2 + 73	1.2 + 73	1.2 + 73	1.2 + 73
	10.5 A	(0.1103 to 1.103) kW	2.6 + 110	2.6 + 110	2.6 + 110	2.6 + 110
320 V	3.2 mA	(0.1024 to 1.024) W	-	1.0 + 0.068	1.1 + 0.11	1.3 + 0.059
	32 mA	(1.024 to 10.24) W	-	1.1 + 0.56	1.1 + 0.56	1.3 + 0.49
	320 mA	(10.24 to 102.4) W	-	1.2 + 5.5	1.2 + 5.5	1.4 + 4.8
	3.2 A	(0.1024 to 1.024) kW	-	1.4 + 73	1.4 + 73	1.6 + 67
	10.5 A	(1.024 to 3.36) kW	-	2.5 + 620	2.5 + 620	2.6 + 610
750 V	3.2 mA	(0.24 to 2.4) W	-	0.81 + 0.87	0.81 + 0.87	1.1 + 0.81
	32 mA	(2.4 to 24) W	-	0.81 + 8.7	0.81 + 8.7	1.1 + 8.2
	320 mA	(24 to 240) W	-	1.2 + 11	1.2 + 11	1.4 + 12
	3.2 A	(0.24 to 2.4) kW	-	1.2 + 720	1.2 + 720	1.4 + 670
	10.5 A	(0.7875 to 7.7875) kW	-	2.6 + 830	2.6 + 830	2.7 + 830

The expanded uncertainties given in this table expressed in mW/W + mW

SCOPE OF CALIBRATION: ELECTRICAL

Matrix E - AC Voltage Source

Range	FREQUENCY							
	(10 – 40) Hz	(40 – 100) Hz	(0.1 – 2) kHz	(2 – 10) kHz	(10 – 30) kHz	(30 – 100) kHz	(100 – 300) kHz	(0.3 – 1) MHz
0 to 200 mV	0.27+ 0.0044	0.25 + 0.0045	0.23 + 0.0023	0.23 + 0.0045	0.48 + 0.0089	0.90 + 0.022	-	-
0.2 V to 2 V	0.20 + 0.022	0.17 + 0.022	0.15 + 0.022	0.17 + 0.022	0.28 + 0.045	0.57 + 0.23	3.4 + 2.3	11 + 23
2 V to 20 V	0.20 + 0.22	0.17 + 0.22	0.15 + 0.22	0.17 + 0.22	0.28 + 0.45	0.57 + 2.3	3.4 + 2.3	11 + 230
20 V to 200 V	0.20 + 2.2	0.17 + 2.2	0.15 + 2.2	0.17 + 2.2	0.28 + 4.5	0.57 + 23	3.4 + 230	11 + 2300
200 V to 1000 V	0.22 + 10	0.20 + 10	0.20 + 10	0.20 + 10	0.30 + 22	0.60 + 110	-	-

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

Matrix F - AC Current Source

Range	FREQUENCY				
	(10 – 40) Hz	(40 – 300) Hz	(0.3 – 1) kHz	(1 – 5) kHz	(5 – 10) kHz
0 to 200 µA	0.38 + 0.022	0.38 + 0.022	0.38 + 0.022	0.38 + 0.022	-
0.2 mA to 2 mA	0.36 + 0.22	0.36 + 0.22	0.36 + 0.22	0.36 + 0.22	-
2 mA to 20 mA	0.35 + 2.3	0.35 + 2.3	0.35 + 2.3	0.35 + 2.3	-
20 mA to 200 mA	0.36 + 22	0.36 + 22	0.36 + 22	0.36 + 22	-
0.2 A to 2 A	0.69 + 450	0.69 + 450	0.69 + 450	2.3 + 910	-
2 A to 10 A	0.63 + 110	0.61 + 100	0.61 + 48	0.61 + 100	0.61 + 100

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

NO: SAMM 122

SCOPE OF CALIBRATION: ELECTRICAL

SITE CALIBRATION: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty (±)*	Remarks
1. Indicating instrument			
DC VOLTAGE	0 μV to 220 mV 0.22 V 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	9.1 μV/V + 0.68μV 7.9 μV/V + 1.1 μV 7.9 μV/V + 4.0 μV 7.9 μV/V + 7.4 μV 9.1 μV/V + 91 μV 10 μV/V + 0.57 mV	Generation using calibrator model Fluke 5700A
	1000 V to 10,000 V	11 mV/V + 3.9 V	Compare with Vitrek 4670B Precision High Voltage Meter
DC CURRENT	0 to 220 μA 0.22 mA to 2.2 mA 2.2 mA to 22 mA 22 mA to 220 mA 0.22 A to 2.2 A	57 μA/A + 9.1 nA 51 μA/A + 9.1 nA 57 μA/A + 91 nA 68 μA/A + 0.91 μA 0.09 mA/A + 28 μA	Generation using calibrator model Fluke 5700A
	0.32 A to 3.2 A 3.2 A to 10.5 A	0.6 mA/A + 0.44 mA 0.6 mA/A + 1.2 mA	Generation using calibrator model Wavetek 9100
	0 A to 500 A	5 mA/A + 0.51 A	Generation using calibrator model Fluke 5500A & 50 turn coil
AC VOLTAGE	0.22 mV to 220 V 220 V to 1050 V	(See Matrix G1) (See Matrix G2)	Generation using calibrator model Fluke 5700A & Wavetek 9100

SCOPE OF CALIBRATION: ELECTRICAL

SITE CALIBRATION: CATEGORY I

<table>
<tr><th>Instrument Calibrated/ Measurement Parameter</th><th>Range</th><th>Calibration and Measurement Capability Expressed as an Uncertainty (±)*</th><th>Remarks</th></tr>
<tr><td colspan="4">1. Indicating instrument</td></tr>
<tr><td rowspan="3">AC CURRENT</td><td>0 µA to 10.5 A</td><td>(See Matrix H)</td><td>Generation using calibrator model Wavetek 9100</td></tr>
<tr><td colspan="2">
<table>
<tr><th rowspan="2">Range</th><th colspan="5">Frequency</th></tr>
<tr><th>(10 to 20) Hz</th><th>(20 to 40) Hz</th><th>(0.04 to 1) kHz</th><th>(1 to 5) kHz</th><th>(5 to 10) kHz</th></tr>
<tr><td>2.2 µA to 220 µA</td><td>0.79 + 0.028</td><td>0.40 + 0.023</td><td>0.16 + 0.018</td><td>0.68 + 0.045</td><td>1.8 + 0.091</td></tr>
<tr><td>0.22 mA to 2.2 mA</td><td>0.79 + 0.045</td><td>0.40 + 0.04</td><td>0.16 + 0.04</td><td>0.68 + 0.45</td><td>1.8 + 0.91</td></tr>
<tr><td>2.2 mA to 22 mA</td><td>0.79 + 0.45</td><td>0.40 + 0.40</td><td>0.16 + 0.40</td><td>0.68 + 4.5</td><td>1.8 + 9.1</td></tr>
<tr><td>22 mA to 220 mA</td><td>0.79 + 4.5</td><td>0.40 + 4.0</td><td>0.16 + 4.0</td><td>0.68 + 45</td><td>1.8 + 91</td></tr>
<tr><td>0.22 A to 2.2 A</td><td>0.74 + 40</td><td>0.74 + 40</td><td>0.74 + 40</td><td>0.85 + 91</td><td>9.6 + 180</td></tr>
</table>
The expanded uncertainties given in this table are expressed in mA/A + µA
</td><td>Generation using calibrator model Fluke 5700A</td></tr>
<tr><td>110 A to 200 A
@ 65 Hz to 440 Hz

110 A to 500 A
@ 45 Hz to 65 Hz</td><td>5.1 mA/A + 0.51 A

5 mA/A + 0.5 A</td><td>Generation using calibrator model Fluke 5500A & 50 turn coil.</td></tr>
</table>

SCOPE OF CALIBRATION: ELECTRICAL

SITE CALIBRATION: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty (±)*	Remarks
**DC POWER	0.0109 mW to 11 kW	(See Matrix I)	Generation using Calibrator model Fluke 5500A
**AC POWER	0.0109 mW to 11 kW @ 10 Hz to 10 kHz	(See Matrix J) Power Factor = 1	Generation using Calibrator model Fluke 5500A
DC RESISTANCE (Specific Value)	1 mΩ 10 mΩ 100 mΩ 1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ	0.87 uΩ 11 uΩ 0.11 mΩ 1.1 mΩ 3.9 mΩ 32 mΩ 0.32 Ω 3.2 Ω 32 Ω	Generation using Standard Resistor model Agilent 42030A (4-Terminal Resistance set)
	1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 kΩ 1.9 kΩ 10 kΩ 19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	0.11 mΩ 0.20 mΩ 0.32 mΩ 0.58 mΩ 1.9 mΩ 3.7 mΩ 15 mΩ 28 mΩ 0.14 Ω 0.26 Ω 1.6 Ω 3.0 Ω 23 Ω 45 Ω 0.45 kΩ 1 kΩ 12 kΩ	Generation using calibrator model Fluke 5700A

SCOPE OF CALIBRATION: ELECTRICAL

SITE CALIBRATION: CATEGORY I

<table>
<tr><th>Instrument Calibrated/ Measurement Parameter</th><th>Range</th><th>Calibration and Measurement Capability Expressed as an Uncertainty (±)*</th><th>Remarks</th></tr>
<tr><td>DC RESISTANCE</td><td>0 Ω to 40 Ω
40 Ω to 400 Ω
400 Ω to 4 kΩ
4 kΩ to 40 kΩ
40 kΩ to 400 kΩ
400 kΩ to 4 MΩ
4 MΩ to 40 MΩ
40 MΩ to 400 MΩ</td><td>0.56 mΩ/Ω + 23 mΩ
0.17 mΩ/Ω + 25 mΩ
0.17 mΩ/Ω + 0.1 Ω
0.17 mΩ/Ω + 1 Ω
0.20 mΩ/Ω + 12 Ω
0.22 mΩ/Ω + 0.14 kΩ
0.56 mΩ/Ω + 2.4 kΩ
0.64 mΩ/Ω + 64 kΩ</td><td>Generation using calibrator model Wavetek 9100</td></tr>
<tr><td>DC RESISTANCE
AT HIGH VOLTAGE
(25 V to 5 kV)</td><td>
<table>
<tr><th>Decade X1</th><th>1kΩ</th><th>10kΩ</th><th>100kΩ</th><th>1MΩ</th><th>10MΩ</th><th>100MΩ</th><th>1GΩ</th></tr>
<tr><td>1</td><td>0.23 Ω</td><td>2.3 Ω</td><td>23 Ω</td><td>0.8 kΩ</td><td>9.8 kΩ</td><td>0.17 MΩ</td><td>4.1 MΩ</td></tr>
<tr><td>2</td><td>0.46 Ω</td><td>4.6 Ω</td><td>46 Ω</td><td>1.6 kΩ</td><td>59 kΩ</td><td>0.33 MΩ</td><td>9.9 MΩ</td></tr>
<tr><td>3</td><td>0.69 Ω</td><td>6.9 Ω</td><td>69 Ω</td><td>6.2 kΩ</td><td>62 kΩ</td><td>0.48 MΩ</td><td>14 MΩ</td></tr>
<tr><td>4</td><td>0.91 Ω</td><td>9.1 Ω</td><td>91 Ω</td><td>6.5 kΩ</td><td>65 kΩ</td><td>0.64 MΩ</td><td>17 MΩ</td></tr>
<tr><td>5</td><td>1.2 Ω</td><td>12 Ω</td><td>0.12 kΩ</td><td>7.0 kΩ</td><td>70 kΩ</td><td>0.80 MΩ</td><td>21 MΩ</td></tr>
<tr><td>6</td><td>1.4 Ω</td><td>14 Ω</td><td>0.14 kΩ</td><td>7.4 kΩ</td><td>74 kΩ</td><td>1.0 MΩ</td><td>25 MΩ</td></tr>
<tr><td>7</td><td>1.6 Ω</td><td>16 Ω</td><td>0.16 kΩ</td><td>8.0 kΩ</td><td>80 kΩ</td><td>1.2 MΩ</td><td>29 MΩ</td></tr>
<tr><td>8</td><td>1.9 Ω</td><td>19 Ω</td><td>0.19 kΩ</td><td>8.5 kΩ</td><td>86 kΩ</td><td>1.3 MΩ</td><td>33 MΩ</td></tr>
<tr><td>9</td><td>2.1 Ω</td><td>21 Ω</td><td>0.21 kΩ</td><td>9.2 kΩ</td><td>92 kΩ</td><td>1.5 MΩ</td><td>37 MΩ</td></tr>
<tr><td>10</td><td>2.3 Ω</td><td>23 Ω</td><td>0.24 kΩ</td><td>9.8 kΩ</td><td>98 kΩ</td><td>1.7 MΩ</td><td>41 MΩ</td></tr>
</table>
</td><td>Generation using Decade Resistance model IET HRRS</td></tr>
<tr><td>AC RESISTANCE
(Specific Value)</td><td>
<table>
<tr><th>Range</th><th>100 kHz</th><th>1 MHz</th><th>2 MHz</th><th>3 MHz</th><th>4 MHz</th><th>5 MHz</th><th>10 MHz</th><th>13 MHz</th></tr>
<tr><td>10 Ω</td><td>-</td><td>3.8 mΩ</td><td>5.6 mΩ</td><td>6.5 mΩ</td><td>7.5 mΩ</td><td>11 mΩ</td><td>41 mΩ</td><td>61 mΩ</td></tr>
<tr><td>100 Ω</td><td>-</td><td>39 mΩ</td><td>47 mΩ</td><td>56 mΩ</td><td>56 mΩ</td><td>56 mΩ</td><td>0.21 Ω</td><td>0.31 Ω</td></tr>
<tr><td>1 kΩ</td><td>0.39 Ω</td><td>0.39 Ω</td><td>0.39 Ω</td><td>0.39 Ω</td><td>0.47 Ω</td><td>0.56 Ω</td><td>2.1 Ω</td><td>3.1 Ω</td></tr>
<tr><td>10 kΩ</td><td>3.2 Ω</td><td>3.9 Ω</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>100 kΩ</td><td>39 Ω</td><td>39 Ω</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
</table>
</td><td>Generation using Standard Resistor model Agilent 42030A (4-Terminal Resistance set)</td></tr>
</table>

SCOPE OF CALIBRATION: **ELECTRICAL**

SITE CALIBRATION: **CATEGORY I**

<table>
<tr><th>Instrument Calibrated/ Measurement Parameter</th><th>Range</th><th>Calibration and Measurement Capability Expressed as an Uncertainty (±)*</th><th>Remarks</th></tr>
<tr><td colspan="4">1. Indicating instrument</td></tr>
<tr><td>CAPACITANCE</td><td colspan="2"><table>
<tr><th rowspan="2">Range</th><th colspan="2">Frequency</th></tr>
<tr><th>≤ 350 Hz</th><th>0.35 to 1.5 kHz</th></tr>
<tr><td>0.5 nF to 4.0 nF</td><td>3.4 mF/F + 17 pF</td><td>3.4 mF/F + 17 pF</td></tr>
<tr><td>4 nF to 40 nF</td><td>3.4 mF/F + 34 pF</td><td>3.4 mF/F + 34 pF</td></tr>
<tr><td>40 nF to 400 nF</td><td>3.4 mF/F + 0.18 nF</td><td>3.4 mF/F + 0.18 nF</td></tr>
<tr><td>400 nF to 4 µF</td><td>4.5 mF/F + 1.8 nF</td><td>4.5 mF/F + 1.8 nF</td></tr>
<tr><td>4 µF to 40 µF</td><td>5.7 mF/F + 18 nF</td><td>5.7 mF/F + 18 nF</td></tr>
<tr><td>40 µF to 400 µF</td><td>5.7 mF/F + 0.18 µF</td><td>5.7 mF/F + 0.18 µF</td></tr>
<tr><td>400 µF to 4 mF</td><td>5.7 mF/F + 1.8 µF</td><td>5.7 mF/F + 1.8 µF</td></tr>
<tr><td>4 mF to 40 mF</td><td>11 mF/F + 68 µF</td><td>11 mF/F + 68 µF</td></tr>
</table></td><td>Generation using calibrator model Wavetek 9100</td></tr>
<tr><td>CAPACITANCE
(Specific Value)</td><td colspan="2"><table>
<tr><th>Range</th><th>1 pF</th><th>10 pF</th><th>100 pF</th><th>1000 pF</th><th>10 nF</th><th>100 nF</th><th>1 uF</th></tr>
<tr><td>120 Hz</td><td>-</td><td>-</td><td>-</td><td>-</td><td>1.2 pF</td><td>12 pF</td><td>0.13 nF</td></tr>
<tr><td>1 kHz</td><td>0.69 fF</td><td>6.9 fF</td><td>0.069 pF</td><td>0.69 pF</td><td>1.2 pF</td><td>12 pF</td><td>0.12 nF</td></tr>
<tr><td>10 kHz</td><td>0.69 fF</td><td>6.9 fF</td><td>0.069 pF</td><td>0.69 pF</td><td>1.2 pF</td><td>12 pF</td><td>0.12 nF</td></tr>
<tr><td>100 kHz</td><td>0.69 fF</td><td>6.9 fF</td><td>0.069 pF</td><td>0.69 pF</td><td>1.2 pF</td><td>12 pF</td><td>0.12 nF</td></tr>
<tr><td>1 MHz</td><td>0.69 fF</td><td>6.9 fF</td><td>0.069 pF</td><td>0.69 pF</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>2 MHz</td><td>0.72 fF</td><td>6.9 fF</td><td>0.069 pF</td><td>0.70 pF</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>3 MHz</td><td>0.80 fF</td><td>6.9 fF</td><td>0.069 pF</td><td>0.74 pF</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>4 MHz</td><td>0.93 fF</td><td>6.9 fF</td><td>0.069 pF</td><td>0.81 pF</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>5 MHz</td><td>1.2 fF</td><td>6.9 fF</td><td>0.070 pF</td><td>0.92 pF</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>10 MHz</td><td>2.6 fF</td><td>6.9 fF</td><td>0.076 pF</td><td>2.1 pF</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>13 MHz</td><td>3.8 fF</td><td>7.0 fF</td><td>0.084 pF</td><td>2.9 pF</td><td>-</td><td>-</td><td>-</td></tr>
</table></td><td>Generation using Standard Capacitor model Agilent 16380A & 16380C (4-Terminal Capacitor Set)</td></tr>
</table>

NO: SAMM 122

SCOPE OF CALIBRATION: **ELECTRICAL**

SITE CALIBRATION: **CATEGORY I**

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty (±)*	Remarks
1. Indicating instrument			
FREQUENCY	0.1 Hz to 1 Hz 1 Hz to 100 Hz 100 Hz to 1 kHz 1 kHz to 10 kHz 10 kHz to 100 kHz 100 kHz to 1 MHz 1 MHz to 10 MHz 10 MHz to 100 MHz 100 MHz to 1 GHz	9.8 nHz/Hz + 0.12 μHz 62 nHz/Hz + 2.2 μHz 81 nHz/Hz + 4.5 μHz 83 nHz/Hz + 26 μHz 83 nHz/Hz + 0.26 mHz 81 nHz/Hz + 4.4 mHz 81 nHz/Hz + 45 mHz 83 nHz/Hz + 0.23 Hz 85 nHz/Hz + 0.03 Hz	Using 10 MHz Reference model Fluke PM6680B
	0.1 Hz to 100 Hz 0.1 kHz to 100 kHz 0.1 MHz to 100 MHz 0.1 GHz to 9 GHz	1.2 uHz/Hz + 0.22 uHz 1.2 uHz/Hz + 4.1 nHz 34 nHz/Hz + 57 uHz 34 nHz/Hz + 7.2 uHz	Generation using Signal Generator model Agilent 33250A, E8663B & SRS FS725 Rubidium Standard (Reference)
2. Oscilloscope			
a. BANDWIDTH	100 mHz to 100 MHz 100.01 MHz to 550 MHz 550.01 MHz to 1.1 GHz	22 mHz/Hz 34 mHz/Hz 43 mHz/Hz	Generation using calibrator model Fluke 9500/9510
	1 GHz to 3 GHz 3 GHz to 6 GHz	34 mHz/Hz + 1.2 MHz 48 mHz/Hz + 0.35 MHz	Generation using Oscilloscope Calibrator model Fluke 9500B & 9560
b. *TIME BASE	@100 mV to 500 mV 180.19 ps – 450 ps 450 ps – 900 ps 0.9 ns – 9 ns @100 mV to 1 V 9 ns - 100 ns 0.1 µs - 10 µs 10 µs - 100 µs 0.1 ms - 10 ms 10 ms - 100 ms 0.1 s - 10 s 10 s - 55 s	0.38 ns/s + 0.072 ps 0.77 ns/s + 0.079 ps 0.48 ns/s + 1.1 ps 0.063 ns/s + 79 ps 0.060 ns/s + 7.2 ns 0.063 ns/s + 79 ns 0.057 ns/s + 7.9 us 0.063 ns/s + 79 us 0.057 ns/s + 7.9 ms 0.046 ns/s + 57 ms	Generation using calibrator model Fluke 9500/9560

SCOPE OF CALIBRATION: ELECTRICAL

SITE CALIBRATION: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty (±)*		Remarks
c. AMPLITUDE	Range	DC Signal (±)		Generation using calibrator model Fluke 9500 & 9510/9560
		Into 50 Ω	Into 1 MΩ	
	35 µV to 1 mV	0.25 mV/V + 26 µV	0.25 mV/V + 25 µV	
	1 mV to 21 mV	0.25 mV/V + 26 µV	0.25 mV/V + 25 µV	
	21 mV to 100 mV	0.25 mV/V + 26 µV	0.25 mV/V + 25 µV	
	100 mV to 556 mV	0.25 mV/V + 26 µV	0.25 mV/V + 45 µV	
	556 mV to 5.5 V	0.25 mV/V + 26 µV	0.25 mV/V + 45 µV	
	5.5 V to 10 V	-	0.25 mV/V + 45 µV	
	10 V to 100 V	-	0.25 mV/V + 81 µV	
	100 V to 210 V	-	0.25 mV/V + 93 µV	
	210 V to 222 V	-	0.25 mV/V + 93 µV	
	Range	Square Signal (10 Hz to 10 kHz)		
		Into 50 Ω	Into 1 MΩ	
	35 µV to 1 mV	10 mV/V + 1.1 µV	10 mV/V + 1.1 µV	
	1 mV to 21 mV	2.4 mV/V + 3.6 µV	2.5 mV/V + 1 µV	
	21 mV to 100 mV	0.99 mV/V + 1.7 µV	0.99 mV/V + 1.8 µV	
	100 mV to 556 mV	0.98 mV/V + 16 µV	0.98 mV/V + 16 µV	
	556 mV to 5.5 V	0.44 mV/V + 0.33 mV	0.47 mV/V + 0.3 mV	
	5.5 V to 10 V	-	0.47 mV/V + 0.3 mV	
	10 V to 100 V	-	0.40 mV/V + 35 mV	
	100 V to 210 V	-	0.40 mV/V + 35 mV	
	210 V to 222 V	-	-	

NO: SAMM 122

SCOPE OF CALIBRATION: **ELECTRICAL**

SITE CALIBRATION: **CATEGORY I**

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty (±)*	Remarks
3. Source			
DC VOLTAGE	0 mV to 100 mV 0.1 V to 1 V 1 V to 10 V 10 V to 100 V 100 V to 1000 V	8.8 uV/V + 0.49 uV 8.2 µV/V + 0.44 µV 8.3 uV/V + 0.93 uV 11 µV/V + 77 µV 24 µV/V + 29 µV	Measurement using Multimeter model Agilent 3458A
	1 kV to 10 kV	0.57 mV/V + 0.57 V	Measurement using High Voltage Meter model Valhalla 4600
AC VOLTAGE	0 to 1000 V	(See Matrix K)	Measurement using Multimeter model Wavetek 1281
	1 kV to 2 kV @ 20 Hz to 60 Hz 2 kV to 15 kV @ 20 Hz to 60 Hz	1.1 mV/V + 2.3 V 5.7 mV/V + 57 V	Measurement using High Voltage Meter model Valhalla 4600
DC CURRENT	0 nA to 100 nA 0.1 uA to 1 uA 1 uA to 10 uA 10 uA to 100 uA 0.1 mA to 1 mA 1 mA to 10 mA 10 mA to 100 mA 0.1 A to 1 A	40 uA/A + 0.077 nA 29 uA/A + 0.089 nA 29 uA/A + 3.3 nA 29 uA/A + 2.7 nA 29 uA/A + 23 nA 29 uA/A + 0.23 uA 46 uA/A + 2.3 uA 0.13 mA/A + 26 uA	Measurement using Multimeter model Agilent 3458A
	1 A to 10 A 10 A to 20 A 20 A to 30 A	16 uA/A + 0.40 mA 48 uA/A + 0.25 mA 0.57 mA/A + 18 uA	Measurement using Multimeter & Current shunt model Agilent 3458A & 34330A
	30 A to 50 A 50 A to 100 A 100 A to 200 A 200 A to 300 A	46 uA/A + 0.72 mA 60 uA/A + 0.41 mA 71 uA/A + 0.21 mA 71 uA/A + 0.14 mA	Measurement using Multimeter & Current shunt model Agilent 3458A & Guildine9230/1000

NO: SAMM 122

SCOPE OF CALIBRATION: **ELECTRICAL**

SITE CALIBRATION: **CATEGORY I**

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty (±)*	Remarks
3. Source			
AC CURRENT	0 to 2 A	(See Matrix L)	Measurement using Multimeter model Wavetek 1281
	2 A to 10 A	(See Matrix L)	Measurement using Multimeter & Current Shunt model Wavetek 1281&4953
DC RESISTANCE	0 to 20 Ω 20 Ω to 200 Ω 0.2 kΩ to 2 kΩ 2 kΩ to 20 kΩ 20 kΩ to 200 kΩ 0.2 MΩ to 2 MΩ 2 MΩ to 20 MΩ 20 MΩ to 200 MΩ 0.2 GΩ to 1GΩ	18 μΩ/Ω + 22 μΩ 13 μΩ/Ω + 65 μΩ 11 μΩ/Ω + 0.63 mΩ 11 μΩ/Ω + 6.3 mΩ 13 μΩ/Ω + 56 mΩ 20 μΩ/Ω + 1.3 Ω 37 μΩ/Ω + 87 Ω 0.35 mΩ/Ω + 10 kΩ 3.5 mΩ/Ω + 0.5 MΩ	Measurement using Multimeter model Wavetek 1281
RF POWER	**Range** / **FREQUENCY**: (100 to 300) kHz; (0.3 to 1) MHz; (0.001 to 2) GHz; (2.0 to 4.2) GHz -30 dBm to 20 dBm (1 μW to 100 mW into 50 Ω): 4.6 %; 3.5 %; 3.3 %; 3.7 %		Measurement using Power Meter & Power Sensor model Agilent EPM441A & 8482A
FREQUENCY	100 mHz to 1 Hz 1 Hz to 100 Hz 100 Hz to 1 kHz 1 kHz to 10 kHz 10 kHz to 100 kHz 100 kHz to 1 MHz 1 MHz to 10 MHz 10 MHz to 100 MHz 100 MHz to 1 GHz 1 GHz to 2.7 GHz	83 nHz/Hz + 1.9 nHz 56 nHz/Hz + 2.9 μHz 85 nHz/Hz + 0.26 μHz 84 nHz/Hz + 11 μHz 83 nHz/Hz + 0.23 mHz 83 nHz/Hz + 1.9 mHz 84 nHz/Hz + 11 mHz 83 nHz/Hz + 0.23 Hz 83 nHz/Hz + 1.9 Hz 77 nHz/Hz + 31 Hz	Measurement using Frequency Counter model Fluke PM6680B
	300 MHz – 12.4 GHz	17 nHz/Hz	Measurement using Frequency Counter & model Agilent 53132A and SRS FS725 Rubidium Standard (Reference)

SCOPE OF CALIBRATION: **ELECTRICAL**

SITE CALIBRATION: **CATEGORY I**

<table>
<tr><th>Instrument Calibrated/ Measurement Parameter</th><th>Range</th><th>Calibration and Measurement Capability Expressed as an Uncertainty (±)*</th><th>Remarks</th></tr>
<tr><td>**TIMER</td><td>1 s to 100 s
100 s to 400 s</td><td>38 us/s + 30 us
34 us/s + 1.8 ms</td><td>Measurement using DSO7104A Oscilloscope</td></tr>
<tr><td>**CAPACITANCE</td><td colspan="2"><table>
<tr><th>Range</th><th>100 Hz</th><th>1 kHz</th><th>10 kHz</th><th>100 kHz</th></tr>
<tr><td>1 pF to 10 pF</td><td>-</td><td>1.2 + 0.00012</td><td>5.0 + 0.000029</td><td>27 + 0.0000054</td></tr>
<tr><td>10 pF to 100 pF</td><td>1.9 + 0.00077</td><td>1.1 + 0.0013</td><td>2.0 + 0.00071</td><td>15 + 0.000099</td></tr>
<tr><td>100 Pf to 1000 pF</td><td>1.80 + 0.0077</td><td>1.1 + 0.013</td><td>1.9 + 0.0073</td><td>14 + 0.0011</td></tr>
<tr><td>1 nF to 10 nF</td><td>1.8 + 0.077</td><td>1.1 + 0.13</td><td>1.9 + 0.074</td><td>14 + 0.011</td></tr>
<tr><td>10 nF to 100 nF</td><td>2.9 + 0.50</td><td>2.9 + 0.50</td><td>2.7 + 0.53</td><td>16 + 0.094</td></tr>
<tr><td>100 nF to 1000 nF</td><td>3.1 + 4.6</td><td>2.0 + 1.2</td><td>3.3 + 4.4</td><td>19 + 0.79</td></tr>
<tr><td>1 uF to 10 uF</td><td>5.8 + 25</td><td>5.4 + 27</td><td>5.4 + 27</td><td>31 + 4.7</td></tr>
<tr><td>10 uF to 100 uF</td><td>13 + 130</td><td>8.8 + 170</td><td>21 + 700</td><td>-</td></tr>
<tr><td>100 uF to 1000 uF</td><td>73 + 200</td><td>47 + 310</td><td>-</td><td>-</td></tr>
<tr><td>1 mF to 10 mF</td><td>-</td><td>55 + 490000</td><td>-</td><td>-</td></tr>
<tr><td>10 mF to 100 mF</td><td>-</td><td>55 + 490000</td><td>-</td><td>-</td></tr>
</table>
The expanded uncertainties given in this table expressed in mF/F + pF</td><td>Measurement using HP 4263A LCR Meter</td></tr>
</table>

Signatories:

1. **Lam Sik Lee**
2. **Mohd Rahimi Bin Samsuddin** (* EOS: Time base only, ** Excluded for EOS)

SCOPE OF CALIBRATION: **ELECTRICAL**

SITE CALIBRATION: **CATEGORY I**

Matrix G1 - AC Voltage Measurement

Range	FREQUENCY							
	(10 to 20) Hz	(20 to 40) Hz	(0.04 to 20) kHz	(20 to 50) kHz	(50 to 100) kHz	(100 to 300) kHz	(300 to 500) MHz	(0.5 to 1.0) MHz
0.22 mV to 2.2 mV	0.62 + 0.0051	0.24 + 0.0051	0.12 + 0.0051	0.42 + 0.0051	0.96 + 0.0079	1.2 + 0.015	1.9 + 0.028	3.9 + 0.028
2.2 mV to 22 mV	0.62 + 0.0057	0.24 + 0.0057	0.12 + 0.0057	0.42 + 0.0057	0.96 + 0.0079	1.2 + 0.014	1.9 + 0.028	3.9 + 0.028
22 mV to 220 mV	0.62 + 0.015	0.24 + 0.0091	0.12 + 0.0091	0.36 + 0.0091	0.96 + 0.028	1.2 + 0.028	1.9 + 0.040	3.9 + 0.12
0.22 V to 2.2 V	0.57 + 0.091	0.18 + 0.028	0.085 + 0.0068	0.14 + 0.018	0.28 + 0.079	0.49 + 0.15	1.2 + 0.040	2.5 + 0.96
2.2 V to 22 V	0.57 + 0.91	0.18 + 0.28	0.085 + 0.068	0.14 + 0.18	0.28 + 0.040	0.57 + 1.7	1.4 + 4.9	3.1 + 9.6
22 V to 220 V	0.57 + 9.1	0.18 + 2.8	0.091 + 0.91	0.25 + 4.0	0.57 + 9.1	1.7 + 100	5.3 + 100	13 + 220

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

Matrix G2 - AC Voltage Measurement

Range	FREQUENCY					
	(15 to 50) Hz	(0.05 to 1) Hz	(1 to 3) kHz	(3 to 10) kHz	(10 to 20) kHz	(20 to 30) kHz
220 V to 1100 V	0.45 + 18	0.091 + 4.0	-	-	-	-
220 V to 320 V	-	-	0.91 + 22	0.91 + 36	1.4 + 48	1.7 + 73
320 V to 800 V	-	-	0.91 + 71	0.91 + 120	1.4 + 180	1.7 + 240
800 V to 1050 V	-	-	0.90 + 150	0.91 + 240	1.4 + 360	-

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

Matrix H - AC Current Measurement

Range	FREQUENCY			
	(0.01 to 3) kHz	(3 to 10) kHz	(10 to 20) kHz	(20 to 30) kHz
0 µA to 32 µA	0.79 + 1	1.1 + 2	2.3 + 6.8	2.8 + 10
32 µA to 320 µA	0.79 + 0.35	1.1 + 0.68	2.3 + 2.3	2.8 + 3.4
0.32 mA to 3.2 mA	0.79 + 0.48	1.1 + 0.68	2.3 + 2.3	2.8 + 3.4
3.2 mA to 32 mA	0.79 + 4.7	1.1 + 7.3	2.3 + 15	2.8 + 25
32 mA to 320 mA	0.91 + 36	1.1 + 55	2.3 + 73	2.8 + 110
0.32 A to 3.2 A	1.1 + 570	2.8 + 2900	-	-
3.2 A to 10.5 A	2.3 + 3400	5.7 + 11000	-	-

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

SCOPE OF CALIBRATION: ELECTRICAL

SITE CALIBRATION: CATEGORY I

Table I: DC Power

Voltage	Current	DC Power	CMC
329.9999 mV	3.29999 mA 32.9999 mA 329.999 mA 2.19999 A 11 A	(0.1089 to 1.089) mW (1.089 to 10.89) mW (10.89 to 108.9) mW (0.0726 to 0.726) W (1.1063 to 3.63) W	0.026 + 0.00056 0.11 + 0.00043 0.11 + 0.0043 0.33 + 0.036 0.65 + 0.29
3.299999 V	3.29999 mA 32.9999 mA 329.999 mA 2.19999 A 11 A	(1.089 to 10.89) mW (10.89 to 108.9) mW (0.1089 to 1.089) W (0.72 to 7.26) W (11.06 to 36.3) W	0.14 + 0.00041 0.1 + 0.0043 0.1 + 0.044 0.32 + 0.35 0.65 + 2.9
32.99999 V	3.29999 mA 32.9999 mA 329.999 mA 2.19999 A 11 A	(10.89 to 108.9) mW (0.1089 to 1.089) W (1.089 to 10.89) W (7.26 to 72.6) W (0.1106 to 0.363) kW	0.14 + 0.0041 0.1 + 0.043 0.1 + 0.44 0.32 + 3.5 0.65 + 29
329.9999 V	3.29999 mA 32.9999 mA 329.999 mA 2.19999 A 11 A	(0.1089 to 1.089) W (1.089 to 10.89) W (10.89 to 108.9) W (0.0726 to 0.726) kW (1.106 to 3.63) kW	0.14 + 0.041 0.1 + 0.43 0.11 + 4.3 0.32 + 35 0.65 + 290
1000 V	3.29999 mA 32.9999 mA 329.999 mA 2.19999 A 11 A	(0.33 to 3.3) W (3.3 to 33) W (0.033 to 0.330) kW (0.22 to 2.2) kW (3.35 to 11) kW	0.08 + 0.53 0.05 + 5.4 0.06 + 54 0.21 + 500 0.69 + 330

The expanded uncertainties given in this table expressed in mW/W + mW

SCOPE OF CALIBRATION: ELECTRICAL

SITE CALIBRATION: CATEGORY I

Table J: AC Power

Voltage	Current	AC Power	(10 to 20) Hz	(20 to 45) Hz	(45 to 65) Hz	(65 to 500) Hz	(0.5 to 1) kHz	(1 to 5) kHz	(5 to 10) kHz
			The expanded uncertainties given in below table expressed in mW/W + uW						
32.999 mV	3.2999 mA	(0.0109 to 0.01089) mW	1.4 + 0.77	1.5 + 0.76	0.37 + 0.78	0.37 + 0.78	0.40 + 0.78	2.5 + 0.75	12 + 0.61
	32.999 mA	(0.1089 to 1.0889) mW	4.2 + 0.52	3.8 + 0.54	1.9 + 0.65	1.9 + 0.65	1.9 + 0.64	6.0 + 0.38	17 + 0.17
	329.99 mA	(1.089 to 10.889) mW	4.5 + 2.2	4.1 + 2.3	2.2 + 2.3	2.2 + 2.3	2.3 + 2.3	6.2 + 1.0	17 + 0.48
	2.19999 A	(7.260 to 72.597) mW	4.5 + 16	4.5 + 16	2.2 + 16	2.2 + 16	2.3 + 16	9.6 + 6.6	2.1 + 93
	11 A	(36.299 to 362.989) mW	-	-	2.1 + 93	2.2 + 91	4.0 + 70	-	-
329.999 mV	3.2999 mA	(0.109 to 1.089) mW	3.0 + 0.48	2.5 + 0.52	0.90 + 0.46	0.77 + 0.68	0.9 + 0.66	5.7 + 0.32	17 + 0.14
	32.999 mA	(1.089 to 10.890) mW	3.4 + 0.69	2.9 + 0.72	1.1 + 0.58	1.1 + 0.58	1.3 + 0.52	5.9 + 0.17	17 + 0.12
	329.99 mA	(10.89 to 108.90) mW	3.4 + 7.1	2.9 + 7.4	1.1 + 4.6	1.1 + 6.3	1.3 + 5.8	5.9 + 1.1	17 + 1.3
	2.19999 A	(72.599 to 725.99) mW	4.1 + 0.23	4.1 + 0.23	1.2 + 60	1.2 + 60	1.4 + 55	9.5 + 26	-
	11 A	(0.3630 to 3.63) W	-	-	0.21 + 7800	0.38 + 7700	2.2 + 6700	-	-
3.29999 V	3.2999 mA	(1.0890 to 10.890) mW	2.6 + 0.44	1.9 + 0.47	1.1 + 0.42	1.2 + 0.41	1.3 + 0.37	5.9 + 0.13	17 + 0.11
	32.999 mA	(10.890 to 108.90) mW	2.6 + 4.4	1.9 + 4.7	1.1 + 4.3	1.1 + 5.3	1.2 + 3.8	5.9 + 1.3	17 + 1.1
	329.99 mA	(0.1089 to 1.089) W	2.6 + 58	1.9 + 52	1.0 + 52	1.0 + 52	1.2 + 47	5.9 + 6.8	17 + 12
	2.19999 A	(0.7260 to 7.260) W	2.7 + 420	2.7 + 420	1.9 + 440	1.2 + 460	1.3 + 420	9.4 + 240	-
	11 A	(3.630 to 36.30) W	-	-	0.71 + 5900	1.1 + 5100	3.5 + 3200	-	-
32.9999 V	3.2999 mA	(10.89 to 108.90) mW	2.6 + 4.8	1.9 + 5.2	1.2 + 5.0	1.6 + 3.9	1.3 + 4.5	5.9 + 1.5	17 + 1.2
	32.999 mA	(0.1089 to 1.089) W	2.6 + 44	1.9 + 47	1.1 + 42	1.1 + 42	1.2 + 38	5.9 + 13	17 + 11
	329.99 mA	(1.089 to 10.890) W	2.6 + 410	1.9 + 430	1.1 + 350	1.1 + 350	1.3 + 310	5.9 + 34	17 + 100
	2.19999 A	(7.260 to 72.599) W	2.7 + 4200	2.7 + 4200	1.2 + 4600	1.2 + 4600	1.3 + 4200	9.4 + 2400	-
	11 A	(36.30 to 363.0) W	-	-	0.75 + 58000	1.2 + 51000	3.5 + 32000	-	-
			The expanded uncertainties given in below table expressed in mW/W + mW						
329.999 V	3.2999 mA	0.1089 W to 1.089 W	-	-	1.2 + 0.041	1.2 + 0.041	1.4 + 0.037	6.0 + 0.015	17 + 0.012
	32.999 mA	1.089 W to 10.89 W	-	-	0.94 + 2.1	0.94 + 2.1	1.1 + 2.0	5.9 + 0.53	17 + 0.25
	329.99 mA	10.89 W to 108.9 W	-	-	1.1 + 4.2	1.1 + 4.1	1.3 + 3.7	6.0 + 1.5	17 + 1.2
	2.19999 A	72.60 W to 726.0 W	-	-	1.2 + 45	1.3 + 45	1.4 + 42	9.4 + 24	-
	11 A	363.0 W to 3630.0 W	-	-	0.81 + 560	1.2 + 500	3.5 + 320	-	-
1000 V	3.2999 mA	(0.330 to 3.30) W	-	-	1.1 + 0.59	1.1 + 0.59	1.3 + 0.56	6.2 + 0.2	17 + 0.19
	32.999 mA	(3.30 to 33.0) W	-	-	1.2 + 1.2	0.99 + 6.1	1.2 + 5.8	6.2 + 2.0	17 + 1.9
	329.99 mA	(33.0 to 330.0) W	-	-	1.1 + 51	1.1 + 51	1.2 + 47	6.2 + 17	17 + 17
	2.19999 A	(220.0 to 2200.0) W	-	-	1.1 + 560	1.1 + 560	1.2 + 540	9.6 + 180	-
	11 A	(1100.0 to 11000.0) W	-	-	0.92 + 730	1.3 + 700	3.6 + 590	-	-

SCOPE OF CALIBRATION: ELECTRICAL

SITE CALIBRATION: CATEGORY I

Matrix K - AC Voltage Source

Range	FREQUENCY							
	(10 – 40) Hz	(40 – 100) Hz	(0.1 – 2) kHz	(2 – 10) kHz	(10 – 30) kHz	(30 – 100) kHz	(100 – 300) kHz	(0.3 – 1) MHz
0 to 200 mV	0.27+ 0.0044	0.25 + 0.0045	0.23 + 0.0023	0.23 + 0.0045	0.48 + 0.0089	0.90 + 0.022	-	-
0.2 V to 2 V	0.20 + 0.022	0.17 + 0.022	0.15 + 0.022	0.17 + 0.022	0.28 + 0.045	0.57 + 0.23	3.4 + 2.3	11 + 23
2 V to 20 V	0.20 + 0.22	0.17 + 0.22	0.15 + 0.22	0.17 + 0.22	0.28 + 0.45	0.57 + 2.3	3.4 + 2.3	11 + 230
20 V to 200 V	0.20 + 2.2	0.17 + 2.2	0.15 + 2.2	0.17 + 2.2	0.28 + 4.5	0.57 + 23	3.4 + 230	11 + 2300
200 V to 1000 V	0.22 + 10	0.20 + 10	0.20 + 10	0.20 + 10	0.30 + 22	0.60 + 110	-	-

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

Matrix L - AC Current Source

Range	FREQUENCY				
	(10 – 40) Hz	(40 – 300) Hz	(0.3 – 1) kHz	(1 – 5) kHz	(5 – 10) kHz
0 to 200 µA	0.38 + 0.022	0.38 + 0.022	0.38 + 0.022	0.38 + 0.022	-
0.2 mA to 2 mA	0.36 + 0.22	0.36 + 0.22	0.36 + 0.22	0.36 + 0.22	-
2 mA to 20 mA	0.35 + 2.3	0.35 + 2.3	0.35 + 2.3	0.35 + 2.3	-
20 mA to 200 mA	0.36 + 22	0.36 + 22	0.36 + 22	0.36 + 22	-
0.2 A to 2 A	0.69 + 450	0.69 + 450	0.69 + 450	2.3 + 910	-
2 A to 10 A	0.63 + 110	0.61 + 100	0.61 + 48	0.61 + 100	0.61 + 100

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

SCOPE OF CALIBRATION: TEMPERATURE

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty (±)*	Remarks
1. Temperature Indicator / Recorder / Controller			
Type K	–250 °C to –200 °C –200 °C to –100 °C –100 °C to +100 °C +100 °C to +600 °C +600 °C to +1372 °C	0.66 °C 0.32 °C 0.23 °C 0.28 °C 0.32 °C	By electrical simulation using Temperature Calibrator and reference table to ITS-90
Type J	–210 °C to –100 °C –100 °C to +800 °C +800 °C to +1000 °C +1000 °C to +1200 °C	0.30 °C 0.23 °C 0.26 °C 0.28 °C	By electrical simulation using Temperature Calibrator and reference table to ITS-90
Type T	–250 °C to –200 °C –200 °C to –100 °C -100 °C to 0 °C 0 °C to +400 °C	0.68 °C 0.32 °C 0.27 °C 0.21 °C	By electrical simulation using Temperature Calibrator and reference table to ITS-90
Type E	-250 °C to -200 °C -200 °C to -100 °C -100 °C to 100 °C 100 °C to 1000 °C	0.66 °C 0.26 °C 0.21 °C 0.25 °C	By electrical simulation using Temperature Calibrator and reference table to ITS-90
Type B	500 °C to 800 °C 800 °C to 1000 °C 1000 °C to 1400 °C 1400 °C to 1820 °C	0.63 °C 0.47 °C 0.39 °C 0.43 °C	By electrical simulation using Temperature Calibrator and reference table to ITS-90
Type N	-200 °C to -100 °C -100 °C to 900 °C 900 °C to 1100 °C 1100 °C to 1300 °C	0.67 °C 0.32 °C 0.26 °C 0.21 °C	By electrical simulation using Temperature Calibrator and reference table to ITS-90

SCOPE OF CALIBRATION: TEMPERATURE

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty (±)*	Remarks
1. Temperature Indicator / Recorder / Controller			
PT100 (PT385 & PT392)	-200 °C to -100 °C -100 °C to 100 °C 100 °C to 630 °C 630 °C to 850 °C	0.18 °C 0.13 °C 0.23 °C 0.34 °C	By electrical simulation using Temperature Calibrator and reference table to ITS-90
2. Temperature Sensors			
THERMOCOUPLE / TEMPERATURE PROBE	0.0 °C 20 °C 20 °C to 50 °C 50 °C to 200 °C 200 °C to 420 °C 420 °C to 550 °C 550 °C to 660 °C	0.074 °C 0.08 °C 0.085 °C 0.30 °C 0.31 °C 0.35 °C 0.37 °C	Comparison with Dry Block RTD Probe & ICE Point PRT Probe
PT100	0.01 °C 20 °C to 50 °C 50 °C to 100 °C 100 °C to 200 °C 200 °C to 420 °C	0.0057 °C 0.035 °C 0.10 °C 0.11 °C 0.14 °C	Comparison with Standard PRT Probe in calibration Triple Point of Water Cell & Dry Block
3. Temperature & Humidity Indicator			
THERMOHYGROGRAPH / THERMOHYGROMETER	20 °C to 40 °C 41 °C to 60 °C	0.68 °C 1.7 °C	Comparison with Reference Temperature & Humidity Meter in Temperature Chamber
	30 %RH to 95 %RH	2.4 %RH	Comparison with Reference Temperature & Humidity Meter in Temperature Chamber

SCOPE OF CALIBRATION: TEMPERATURE

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty (±)*	Remarks
4. Temperature Calibrator / Simulator			
Type K	-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	0.33 °C 0.18 °C 0.16 °C 0.26 °C 0.40 °C	By electrical measurement using Temperature Calibrator
Type J	-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	0.27 °C 0.16 °C 0.14 °C 0.17 °C 0.23 °C	By electrical measurement using Temperature Calibrator
Type T	-250 °C to -150 °C -150 °C to 0 °C 0 °C to 120 °C 120 °C to 400 °C	0.63 °C 0.24 °C 0.16 °C 0.14 °C	By electrical measurement using Temperature Calibrator
Type E	-250 °C to -100 °C -100 °C to -25 °C -25 °C to 350 °C 350 °C to 650 °C 650 °C to 1000 °C	0.50 °C 0.16 °C 0.14 °C 0.16 °C 0.21 °C	By electrical measurement using Temperature Calibrator
Type B	600 °C to 800 °C 800 °C to 1000 °C 1000 °C to 1550 °C 1550 °C to 1820 °C	0.44 °C 0.34 °C 0.30 °C 0.33 °C	By electrical measurement using Temperature Calibrator
Type N	-200 °C to -100 °C -100 °C to -25 °C -25 °C to 120 °C 120 °C to 410 °C 410 °C to 1300 °C	0.40 °C 0.22 °C 0.19 °C 0.18 °C 0.27 °C	By electrical measurement using Temperature Calibrator

Signatories:

1. **Lam Sik Lee**
2. **Mohd Rahimi Bin Samsuddin** (Except for item 2 & 4)

SCOPE OF CALIBRATION: **TEMPERATURE**

SITE CALIBRATION: **CATEGORY I**

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty (±)*	Remarks
5. Temperature Indicator / Recorder / Controller			
Type K	–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	0.38 °C 0.22 °C 0.19 °C 0.30 °C 0.46 °C	By electrical simulation using Temperature Calibrator
Type J	–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	0.32 °C 0.19 °C 0.17 °C 0.21 °C 0.27 °C	By electrical simulation using Temperature Calibrator
Type T	–250 °C to –150 °C -150 °C to 0 °C 0 °C to +120 °C +120 °C to +400 °C	0.72 °C 0.28 °C 0.19 °C 0.17 °C	By electrical simulation using Temperature Calibrator
Type E	-250 °C to -100 °C -100 °C to -25 °C -25 °C to 350 °C 350 °C to 650 °C 650 °C to 1000 °C	0.50 °C 0.16 °C 0.14 °C 0.16 °C 0.21 °C	By electrical simulation using Temperature Calibrator and reference table to ITS-90
Type B	600 °C to 800 °C 800 °C to 1000 °C 1000 °C to 1550 °C 1550 °C to 1820 °C	0.44 °C 0.34 °C 0.30 °C 0.33 °C	By electrical simulation using Temperature Calibrator and reference table to ITS-90
Type N	-200 °C to -100 °C -100 °C to -25°C -25 °C to 120 °C 120 °C to 410 °C 410 °C to 1300 °C	0.40 °C 0.22 °C 0.19 °C 0.18 °C 0.27 °C	By electrical simulation using Temperature Calibrator and reference table to ITS-90

SCOPE OF CALIBRATION: **TEMPERATURE**

SITE CALIBRATION: **CATEGORY I**

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty (±)*	Remarks
5. Temperature Indicator / Recorder / Controller			
PT100 (PT385 & PT392)	-200 °C to -100 °C -100 °C to 100 °C 100 °C to 630 °C 630 °C to 850 °C	0.18 °C 0.13 °C 0.23 °C 0.34 °C	By electrical simulation using Temperature Calibrator and reference table to ITS-90
6. Temperature Sensor			
THERMOCOUPLE / TEMPERATURE PROBE	0.0 °C 50 °C to 200 °C 200 °c to 420 °C 420 °C to 550 °C 550 °C to 660 °C	0.074 °C 0.30 °C 0.31 °C 0.35 °C 0.37 °C	Comparison with Dry Block RTD Probe & ICE Point PRT Probe
7. Temperature Calibrator / Simulator			
Type K	-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	0.33 °C 0.18 °C 0.16 °C 0.26 °C 0.40 °C	By Electrical measurement using Temperature Calibrator
Type J	-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	0.27 °C 0.16 °C 0.14 °C 0.17 °C 0.23 °C	By Electrical measurement using Temperature Calibrator
Type T	-250 °C to -150 °C -150 °C to 0 °C 0 °C to 120 °C 120 °C to 400 °C	0.63 °C 0.24 °C 0.16 °C 0.14 °C	By Electrical measurement using Temperature Calibrator

SCOPE OF CALIBRATION: **TEMPERATURE**

SITE CALIBRATION: **CATEGORY I**

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty (±)*	Remarks
7. Temperature Calibrator / Simulator			
Type E	-250 °C to -100 °C -100 °C to -25 °C -25 °C to 350 °C 350 °C to 650 °C 650 °C to 1000 °C	0.50 °C 0.16 °C 0.14 °C 0.16 °C 0.21 °C	By Electrical measurement using Temperature Calibrator
Type B	600 °C to 800 °C 800 °C to 1000 °C 1000 °C to 1550 °C 1550 °C to 1820 °C	0.44 °C 0.34 °C 0.30 °C 0.33 °C	By Electrical measurement using Temperature Calibrator
Type N	-200 °C to -100 °C -100 °C to -25 °C -25 °C to 120 °C 120 °C to 410 °C 410 °C to 1300 °C	0.40 °C 0.22 °C 0.19 °C 0.18 °C 0.27 °C	By Electrical measurement using Temperature Calibrator
8. Temperature Controlled Enclosure			
TEMPERATURE CONTROLLED ENCLOSURE	-20 °C to 100 °C 100 °C to 400 °C	1.9 °C 2.0 °C	Calibration using Thermocouple Sensor & meter (Based on G-20 Document Thailand)

Signatories:

1. **Lam Sik Lee**
2. **Mohd Rahimi Bin Samsuddin** (Except for item 6, item 7 & item 8)