LABORATORY LOCATION:
(PERMANENT LABORATORY)

SENDI MAHIR SDN. BHD.
NO. 6, 8 & 10,12 JALAN KAPAR 27/89
MEGAH INDUSTRIAL PARK
40400 SHAH ALAM, SELANGOR
MALAYSIA

FIELDS OF CALIBRATION: **FORCE, TORQUE, DIMENSIONAL, MASS, FLOW, PRESSURE, TEMPERATURE, VOLUMETRIC, ELECTRICAL & OPTICAL AND PHOTOMETRIC MEASUREMENTS**

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.**

SCOPE OF CALIBRATION: FORCE

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Push-Pull Gauge	0 kgf to 100 kgf	0.5 % of reading	Calibrated using Deadweight Standard Weight based on ISO 376:2004
Tension Gauge	0 kgf to 100 kgf	0.5 % of reading	
Load Measuring Device			Calibrated using Load Cell, Proving Ring and Tension/ Compression Testing Machine based on ISO 376:2004
Tension	0 kgf to 500 kgf 500 kgf to 1 tonf 1 tonf to 5 tonf 5 tonf to 10 tonf 10 tonf to 30 tonf	15 gf 0.58 kgf 1.7 kgf 13 kgf 79 kgf	
Compression	0 kgf to 500 kgf 500 kgf to 1 tonf 1 tonf to 5 tonf 5 tonf to 10 tonf 10 tonf to 30 tonf 30 tonf to 40 tonf	15 gf 0.56 kgf 1.7 kgf 13 kgf 79 kgf 93 kgf	

SCOPE OF CALIBRATION: FORCE

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Shore Hardness Tester (spring load)			
1. Type A, B, E, O	0 to 100 shore hardness index	0.24 shore hardness index	Calibrated using Durometer tester based on ASTM D 2240:2005
2. Type C, D, DO	0 to 100 shore hardness index	0.23 shore hardness index	
3. Type OO	0 to 100 shore hardness index	0.23 shore hardness index	
Adhesion Tester (pressure)	0 N/mm^2 to 25 N/mm^2	0.14 N/mm^2	Calibrated using Load Cell based on ASTM D 4541:2009

Signatory:

1. **Seah Leong Ho**

SCOPE OF CALIBRATION: FORCE

SITE: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Universal Testing Machine 1. Tensile mode (0~10,000 kgf) 2. Compress mode (0~200,000 kgf)	0 kgf to 500 kgf 500 kgf to 1,000 kgf 1,000 kgf to 5,000 kgf 5,000 kgf to 10,000 kgf 10,000 kgf to 50,000 kgf 50,000 kgf to 200,000 kgf	24 gf 0.26 kgf 1 kgf 15 kgf 60 kgf 260 kgf	Calibrated using Deadweight up to 500 kgf or Load Cell based on ISO 7500-1:2004
Hardness Tester	20 HRA to 88 HRA 30 HRB to 100 HRB 10 HRC to 70 HRC	± 0.6 HRA ± 0.6 HRB ± 0.6 HRC	Calibrated using Load Cell and Hardness Block set based on ISO 6508-2:2005 under method clause 5 indirect verification

Signatory:

1. **Seah Leong Ho**

SCOPE OF CALIBRATION: TORQUE

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Torque Measuring Device	0 N.m to 1 N.m 1 N.m to 10 N.m 10 N.m to 100 N.m 100 N.m to 500 N.m 500 N.m to 1,000 N.m	0.52 % of reading 0.33 % of reading 0.19 % of reading 0.15 % of reading 0.15 % of reading	Calibrated using ERM and Torque Transducer or Torque Bar based on BS 7882:2008
Torque Tools Device (Torque wrench and Torque Driver)	0. N.m to 1 N.m 1 N.m to 10 N.m 10 N.m to 100 N.m 100 N.m to 500 N.m 500 N.m to 1,000 N.m 1,000 N.m to 3,000 N.m	0.52 % of reading 0.33 % of reading 0.19 % of reading 0.15 % of reading 0.15 % of reading 0.26 % of reading	Calibrated using ERM and Torque Transducer or Torque Bar based on ISO 6789-1:2017 (E)

Signatory:

1. **Seah Leong Ho**

SCOPE OF CALIBRATION: DIMENSIONAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Plain Plug Gauge / Pin Gauge (Diameter)	0 mm to 10 mm 10 mm to 100 mm 100 mm to 300 mm	0.2 µm 0.4 µm 1.0 µm	Calibrated using ULM
Plain Ring Gauge (Diameter)	0 mm to 10 mm 10 mm to 100 mm 100 mm to 300 mm	0.4 µm 0.5 µm 1.0 µm	Calibrated using ULM
External Micrometer 50 mm frame 100 mm frame 150 mm frame 200 mm frame 300 mm frame 400 mm frame 450 mm frame 600 mm frame	 Up to 25 mm 25 mm tranverse 25 mm tranverse 25 mm tranverse 25 mm tranverse 25 mm tranverse 25 mm tranverse 25 mm tranverse	 1 µm 1.1 µm 1.2 µm 1.3 µm 1.6 µm 2 µm 2.5 µm 2.5 µm	Calibrated using Gauge Blocks based on BS EN ISO 3611:2010
Caliper Checker	0 mm to 600 mm	3 µm	Calibrated using Gauge Blocks based on ISO 7863:1984
Dial / Digimatic & Vernier Caliper	0 mm to 200 mm 200 mm to 450 mm 450 mm to 1,000 mm 1,000 mm to 1,500 mm 1,500 mm to 2,000 mm	5 µm 7 µm 7.5 µm 17 µm 23 µm	Calibrated using Gauge Blocks based on BS EN ISO 13385-1:2011
Dial Gauge	0 mm to 50 mm	1.5 µm	Calibrated using Dial Gauge Calibrator based on BS 907:2008
Dial Test Indicator	0 mm to 50 mm	1.5 µm	Calibrated using Dial Gauge Calibrator based on BS 2795:1981
Dial / Digimatic & Vernier Height Gauge	0 mm to 450 mm 450 mm to 600 mm 600 mm to 1,000 mm	7 µm 7.5 µm 7.7 µm	Calibrated using Gauge Blocks based on BS EN ISO 13225:2012
Height Setting Micrometer & Riser Block	0 mm to 600 mm	3 µm	Calibrated using Gauge Blocks based on ISO 7863:1984

SCOPE OF CALIBRATION: DIMENSIONAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Screw Plug (simple pitch diameter)	0 mm to 20 mm 20 mm to 100 mm	0.5 µm 1.0 µm	Calibrated using ULM
Screw Ring (simple pitch diameter)	0 mm to 20 mm 20 mm to 100 mm	0.5 µm 1.0 µm	Calibrated using ULM
Gauge Block Set Grade '0' and below	0 mm to 10 mm 10 mm to 25 mm 25 mm to 50 mm 50 mm to 75 mm 75 mm to 100 mm	0.12 µm 0.12 µm 0.13 µm 0.14 µm 0.16 µm	Calibrated using Gauge Blocks based on ISO 3650:1998
Steel Rulers	0 mm to 1,000 mm 1,000 mm to 3,000 mm	0.2 mm 0.5 mm	Calibrated using Standard Scale based on JIS B 7516:2005
Vee Blocks	220 mm x 160 mm x 80 mm	4 µm	Calibrated using Dial Test Indicator based on JIS B 7540:1972
Bubble Levelling Gauge	Height in respect to length 0.02 mm/m to 0.25 mm/m	6 µm/m	Calibrated using Bubble Tube Tester and Dial Test Indicator based on JIS B 7510:1993
Cylinder Gauge	0 mm to 600 mm	1 µm	Calibrated using ULM and Gauge Blocks based on JIS B 7515:1982
Internal Micrometer	0 mm to 25 mm 25 mm to 100 mm 100 mm to 600 mm	1.5 µm 2 µm 10 µm	Calibrated using ULM and Gauge Blocks based on BS 959:2008
Setting Rod	0 mm to 25 mm 25 mm to 100 mm 100 mm to 600 mm	0.3 µm 0.5 µm 2.2 µm	Calibrated using ULM and Gauge Blocks based on BS 870:2008

SCOPE OF CALIBRATION: DIMENSIONAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Thickness Coating Film	0 mm to 2.5 mm	0.2 µm	Calibrated using ULM and Gauge Blocks based on BS 5411
Pitch Gauge	0 mm to 12 mm	10 µm	Calibrated using Profile Projector
Radius Gauge	0 mm to 100 mm	10 µm	Calibrated using Profile Projector
Test Sieves	0 mm to 200 mm	10 µm	Calibrated using Profile Projector
Mµ Checker	0 mm to 3 mm	0.2 µm	Calibrated using Gauge Blocks based on JIS B 7536 : 1982
Feeler Gauge (Thickness)	0.01 mm to 10 mm	2 µm	Calibrated using Precision Micrometer based on BS 957:2008
Dial Gauge Calibrator	0 mm to 25 mm	0.2 µm	Calibrated using Precision Digital Linear Probe based on JIS B 7519:1994
Depth Gauge	0 mm to 25 mm 25 mm to 100 mm 100 mm to 300 mm	1.4 µm 1.5 µm 2.0 µm	Calibrated using Gauge Blocks based on BS 6468:2008
Thickness Gauge	0 mm to 10 mm 10 mm to 65 mm	1.2 µm 1.4 µm	Calibrated using Gauge Blocks based on JIS B 7519:1994
Snap Gauge	0 mm to 100 mm 100 mm to 200 mm	0.4 µm 0.6 µm	Calibrated using ULM and Setting Ring

SCOPE OF CALIBRATION: DIMENSIONAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
<u>Taper Plain Plug</u> Diameter	0 mm to 20 mm 20 mm to 300 mm	0.5 µm 1.0 µm	Calibrated using ULM and Setting Ring
Angle		0.003°	Calibrated using ULM
<u>Taper Plain Ring</u> Diameter	0 mm to 20 mm 20 mm to 300 mm	0.5 µm 1.0 µm	Calibrated using ULM and Setting Ring
Angle		0.003°	Calibrated using ULM
<u>Taper Thread Plug</u> Pitch Diameter	0 mm to 20 mm 20 mm to 100 mm	0.5 µm 1.0 µm	Calibrated using ULM
Angle		0.002°	Calibrated using ULM
<u>Taper Thread Ring</u> Pitch Diameter	0 mm to 20 mm 20 mm to 100 mm	0.5 µm 1.0 µm	Calibrated using ULM and Setting Ring
Angle		0.002°	Calibrated using ULM
Length Bar	125 mm 150 mm 175 mm 200 mm 250 mm 300 mm 400 mm 500 mm	0.63 µm 0.71 µm 0.79 µm 0.87 µm 1.0 µm 1.2 µm 1.6 µm 2.3 µm	Calibrated using ULM and Gauge Blocks

SCOPE OF CALIBRATION: DIMENSIONAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Measuring Tape 1. Steel type	Up to 1,000 mm 2,000 mm 5,000 mm 8,000 mm 10,000 mm 20,000 mm 30,000 mm 50,000 mm 100,000 mm	0.12 mm 0.17 mm 0.26 mm 0.33 mm 0.37 mm 0.53 mm 0.64 mm 0.83 mm 1.2 mm	Calibrated using scale and tape calibration unit based on JIS B 7512:1993
2. Fabric type	Up to 1,000 mm 2,000 mm 5,000 mm 8,000 mm 10,000 mm 20,000 mm 50,000 mm 100,000 mm	0.12 mm 0.17 mm 0.27 mm 0.34 mm 0.38 mm 0.53 mm 0.84 mm 1.2 mm	Calibrated using scale and tape calibration unit based on JIS B 7522:2005
Holtest	0 mm to 175 mm 175 mm to 200 mm	1 µm 2 µm	Calibrated using Master Ring Gauge based on DIN 863-4:1999 for repeatability test only
Bevel Protractor	0° to 360°	0.6°	Calibrated using inclinometer and Feeler Gauge based on BS 1685:2008

Signatories:

1. **Seah Leong Ho**
2. **Chin Inn Nkot**
3. **Kayalvili a/p Munusamy**
4. **Norita binti Md. Ali**

SCOPE OF CALIBRATION: DIMENSIONAL

SITE: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Measuring Projector (individual linear axis only)	0 mm to 50 mm 50 mm to 100 mm 100 mm to 200 mm 200 mm to 300 mm	1.7 µm Magnification 0.1% 1.9 µm Magnification 0.1% 2.5 µm Magnification 0.1% 3.5 µm Magnification 0.1%	Calibrated using Glass Scale, Precision Ball and Reading Scale based on JIS B7184:1999
Co-Ordinate Measuring Machine	0 mm to 1,000 mm	10 µm	Calibrated using Ball Bar Set, Long Gauge Block, Gauge Block Set and Thermometer with Sensor based on ANSI/ASME B89:1997
Caliper	0 mm to 1,000 mm 1,000 mm to 1,500 mm 1,500 mm to 2,000 mm	7.5 µm 17 µm 23 µm	Calibrated using Gauge Blocks based on BS EN ISO 13385-1:2011
Micrometer (External)	0 mm to 600 mm	2.5 µm	Calibrated using Gauge Blocks based on BS EN ISO 3611-2010
Linear Height Gauge	0 mm to 1,000 mm	7.5 µm	Calibrated using Gauge Blocks based on BS EN ISO 13225 : 2012

SCOPE OF CALIBRATION: DIMENSIONAL

SITE: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Surface Plate Flatness	600 mm x 600 mm 800 mm x 800 mm 1m x1m	1.3 µm 1.8 µm 2.2 µm	Calibrated using Planekator, Repeat-O-Meter and Micro-Comparator based on BS 817:2008

Signatories:

1. **Seah Leong Ho**
2. **Chin Inn Nkot**

SCOPE OF CALIBRATION: DIMENSIONAL

SITE: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Measuring Microscope (Individual linear axis only)	0 mm to 200 mm	2.2 µm	Calibrated using Glass Scale based on JIS B 7153:1995

Signatories:

1. **Seah Leong Ho**

SCOPE OF CALIBRATION: MASS

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Standard Weight	1 mg 2 mg 5 mg 10 mg 20 mg 50 mg 100 mg 200 mg 500 mg 1 g 2 g 5 g 10 g 20 g 50 g 100 g 200 g 500 g 1 kg 2 kg 5 kg 10 kg 20 kg 25 kg	3 µg 3 µg 3 µg 3 µg 3 µg 3 µg 3 µg 3 µg 4 µg 4 µg 7 µg 10 µg 20 µg 30 µg 60 µg 0.13 mg 0.26 mg 0.67 mg 1.3 mg 2.6 mg 6.7 mg 26 mg 52 mg 0.15 g	Calibrated using Standard Weight Sets and Mass Comparator based on OIML R111-2:2004

Signatory:

1. **Seah Leong Ho**

SCOPE OF CALIBRATION: MASS

SITE: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Analytical Balance and Weighing Scale	0 g to 5 g 0 g to 20 g 0 g to 50 g 0 g to 100 g 0 g to 200 g 0 g to 500 g 0 kg to 1 kg 0 kg to 2 kg 0 kg to 3 kg 0 kg to 5 kg 0 kg to 10 kg 0 kg to 20 kg 0 kg to 30 kg 0 kg to 50 kg 0 kg to 100 kg 0 kg to 200 kg 0 kg to 500 kg 0 kg to 750 kg 0 kg to 1,000 kg 0 kg to 1,500 kg 0 kg to 2,000 kg	20 µg 20 µg 0.15 mg 0.11 mg 0.20 mg 0.50 mg 1.0 mg 2.0 mg 2.2 mg 5.0 mg 47 mg 96 mg 1.1 g 2.0 g 5.0 g 9.0 g 20 g 45 g 47 g 54 g 94 g	Calibrated using Standard Weight Sets based on ASTM E898:2005
Standard Weight	1 kg 2 kg 5 kg 10 kg 20 kg 25 kg	14 mg 14 mg 16 mg 0.14 g 0.15 g 0.15 g	Calibrated using Standard Weight Sets and Mass Comparator based on OIML R111-2:2004

Signatory:

1. **Seah Leong Ho**

SCOPE OF CALIBRATION: PRESSURE

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Pressure Measuring Device			
Vacuum	0 bar to -0.95 bar	0.42 mbar	Calibrated using Multifunction Calibrator based on AS 1349:1987
Pneumatic	0 bar to 20 bar	7 mbar	
Hydraulic	1 bar to 700 bar	0.015% of reading	Calibrated using Deadweight Tester based on AS 1349:1987
	700 bar to 1,100 bar	0.015% of reading	

Signatories:

1. **Seah Leong Ho**
2. **Shahizan Hardy bin Abd Razak**

SCOPE OF CALIBRATION: PRESSURE

SITE: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Pressure Measuring Device	-700 mbar to 700 mbar 0 bar to 20 bar 0 psi to 11,000 psi	1.7 mbar 50 mbar 0.025 % of reading	Calibrated using Pressure Calibrator based on AS 1349:1987

Signatory:

1. **Seah Leong Ho**

SCOPE OF CALIBRATION: FLOW

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Anemometer	0.15 m/s to 5 m/s 5 m/s to 20 m/s 20 m/s to 45 m/s	0.12 m/s 0.24 m/s 0.54 m/s	Calibrated using Anemometer Calibrator

Signatory:

1. **Seah Leong Ho**

SCOPE OF CALIBRATION: TEMPERATURE

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Temperature Measuring Device	-20 °C to 50 °C	0.2° C	Calibrated using Temperature Recorder, PRT, Humidity Chamber and Thermohygrometer based on JIS B7306:1989 and JIS Z8806:1995
Relative Humidity Measuring Device	20 %RH to 95 %RH	2 %RH	
Liquid-In-Glass Thermometer (Total & Partial Immersion)	-30 °C to 0 °C 0 °C to 250 °C 250 °C to 400 °C	0.024 °C 0.041 °C 0.11 °C	Calibrated using Resistance Thermometer Display & PRT, Temperature Recorder, Constant Stirred Low Temperature Liquid Bath, Constant Stirred High Temperature Liquid Bath, Metal Block Bath and Ice Point based on ASTM E77:2007
Temperature Sensor (Thermocouple, PRT, Mechanical Thermometer & Thermistor)	-95 °C to -50 °C -50 °C to -30°C -30 °C to 0 °C 0 °C to 250 °C 250 °C to 400 °C 400 °C to 660 °C 660 °C to 800 °C 800 °C to 1,000 °C 1,000 °C to 1,200 °C	0.063 °C 0.062 °C 0.024 °C 0.041 °C 0.11 °C 0.13 °C 2.1 °C 3.1 °C 4.0 °C	Calibrated using Resistance Thermometer Display & PRT, Type R Thermocouple, Temperature Recorder, Constant Stirred Low Temperature Liquid Bath, Constant Stirred High Temperature Liquid Bath, Temperature Block Calibrator and Ice Point based on JIS C1602:1995, JIS C 1604:1997, JIS C1611:1995 and JIS Z 8710:1993

SCOPE OF CALIBRATION: TEMPERATURE

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Temperature Block Calibrator	-95 °C to -50 °C -50 °C to 660 °C 660 °C to 1,200 °C	0.057 °C 0.013 °C 2.7 °C	Calibrated using PRT, Thermocouple Type R and Temperature Display based on EA-10/13:1999
Liquid Bath	-50 °C to 300 °C	0.012 °C	
Temperature Indicating Device Resistance Type PT100	-200 °C to 650 °C 650 °C to 850 °C	0.1 °C 0.1 °C	Calibrated by electrical simulation using Calibrator and Ice point based on JIS C 1601:1983 and JIS C 1603:1983
Thermocouple Type			
K	-270 °C to -100 °C -100 °C to 1,370 °C	1.5 °C 0.1 °C	
J	-210 °C to 1,200 °C	0.1 °C	
T	-270 °C to -100 °C -100 °C to 400 °C	0.5 °C 0.1 °C	
E	-270 °C to -100 °C -100 °C to 1,000 °C	0.3 °C 0.1 °C	
R	0 °C to 500 °C 500 °C to 1,760 °C	0.4 °C 0.1 °C	
S	0 °C to 500 °C 500 °C to 1,760 °C	0.4 °C 0.1 °C	
N	-100 °C to 1,300 °C	0.1 °C	

SCOPE OF CALIBRATION: TEMPERATURE

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Temperature Calibrator Resistance Type PT100	-200 °C to 650 °C 650 °C to 850 °C	0.1 °C 0.1 °C	Calibrated by electrical measurement using Multimeter and Ice Point based on JIS Z 8704:1993 and ITS 90:1990
JPT100	-200 °C to 500 °C	0.1 °C	
Thermocouple Type K	-270 °C to -100 °C -100 °C to 1,370 °C	1.5 °C 0.1 °C	
J	-210 °C to 1,200 °C	0.1 °C	
T	-270 °C to -100 °C -100 °C to 400 °C	0.5 °C 0.1 °C	
E	-270 °C to -100 °C -100 °C to 1,000 °C	0.3 °C 0.1 °C	
N	-270 °C to -100 °C -100 °C to 1,300 °C	1.5 °C 0.1 °C	
B	100 °C to 500 °C 500 °C to 1,820 °C	1.5 °C 0.3 °C	
R	0 °C to 500 °C 500 °C to 1,760 °C	0.4 °C 0.2 °C	
S	0 °C to 500 °C 500 °C to 1,760 °C	0.4 °C 0.2 °C	
Radiation Thermometer	-20 °C to 150 °C 150 °C to 200 °C 200 °C to 400 °C 400 °C to 1,000 °C 1,000 °C to 1,300 °C	0.39 °C 0.93 °C 0.99 °C 2.0 °C 3.6 °C	Calibrated using Temperature Recorder, Thermocouple, Single Blackbody Calibrator and Cyclops Spherical Blackbody Source based on ASTM E 1256:2007

Signatories:

1. **Seah Leong Ho**
2. **Mohamad Azlan bin Mohamed Aris**

SCOPE OF CALIBRATION: TEMPERATURE

SITE: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Temperature Sensor (Thermocouple, PRT, Mechanical Thermometer & Thermistor)	-30 °C to 30 °C 30 °C to 650 °C	0.051 °C 0.17 °C	Calibrated using Resistance Thermometer Display & PRT, Temperature Recorder, Constant Stirred Temperature Liquid Bath, Constant Stirred High Temperature Liquid Bath, Temperature Block Calibrator and Ice Point based on JIS C 1602:1995, JIS C 1604:1997, JIS C 1611:1995 and JIS Z 8710:1993
Temperature Controlled Enclosure	-80 °C to -20 °C -20 °C to 250 °C 250 °C to 800 °C 800 °C to 1,000 °C 1,000 °C to 1,200 °C	0.6 °C 1 °C 2 °C 3 °C 5 °C	Calibrated using Temperature Recorder, PRT and Thermocouple based on AS 2853:1986
Liquid Bath	-30 °C to 300 °C	0.1 °C	
Humidity Controlled Enclosure	30 %RH to 98 %RH	5 %RH	Calibrated using Temperature Recorder, PRT, Thermocouple and Barometer based on AS 2853:1986 and BS 1339-3:2004

SCOPE OF CALIBRATION: TEMPERATURE

SITE: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Temperature Indicating Device			Calibrated by electrical simulation using Calibrator and Ice Point based on JIS C1601:1983 and JIS C1603:1983
Resistance Type			
PT100	-200 °C to 650 °C	0.1 °C	
JPT100	-200 °C to 500 °C	0.1 °C	
Thermocouple Type			
K	-270 °C to -100 °C	1.5 °C	
	-100 °C to 1,370 °C	1 °C	
J	-210 °C to 1,200 °C	1 °C	
T	-270 °C to 400 °C	1 °C	
E	-270 °C to 1,000 °C	1 °C	
R	0 °C to 1,760 °C	1 °C	
S	0 °C to 1,760 °C	1 °C	
N	-100 °C to 1,300 °C	1 °C	

Signatories:

1. **Seah Leong Ho**
2. **Mohd Safiee bin Ngadirin**

SCOPE OF CALIBRATION: VOLUMETRIC

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Burette	1 ml to 10 ml 10 ml to 25 ml 25 ml to 50 ml 50 ml to 100 ml	6 µl 20 µl 30 µl 70 µl	Calibrated using Analytical Balance and Distilled Water based on ISO 385:2005(E)
Measuring Cylinder	5 ml 5 ml to 10 ml 10 ml to 25 ml 25 ml to 100 ml 100 ml to 250 ml 250 ml 500 ml 500 ml to 1,000 ml 1,000 ml to 2,000 ml	40 µl 70 µl 0.2 ml 0.4 ml 0.7 ml 1.6 ml 3 ml 5 ml	Calibrated using Analytical Balance and Distilled Water based on ISO 4788:2005(E)
One Mark Volumetric Flask	5 ml to 10 ml 10 ml to 25 ml 25 ml to 100 ml 100 ml to 500 ml 500 ml 2,000 ml	20 µl 30 µl 60 µl 0.2 ml 0.3 ml	Calibrated using analytical Balance and Distilled Water based on ISO 1042:1998
Pipette	Type 1, Type 2, Type 3 0.5 ml to 1 ml 1 ml to 2 ml 2 ml to 5 ml 5 ml to 10 ml 10 ml to 25 ml	 4 µl 7 µl 15 µl 29 µl 57 µl	Calibrated using Analytical Balance and Distilled Water based on ISO 835:2007(E)
	25 ml to 100 ml	7 µl	Calibrated using Analytical Balance and Distilled Water based on ISO 4787:2010
Piston Operated Volumetric Apparatus (POVA)	10 µl to 200 µl 200 µl to 500 µl 500 µl to 1,000 µl 1 ml to 2 ml 2 ml to 5 ml 5 ml to 10 ml	0.10 µl 0.12 µl 0.15 µl 0.25 µl 0.57 µl 1.20 µl	Calibrated using Analytical Balance and Distilled Water based on ISO 8655-6:2002 and ISO 8655-2:2002

SCOPE OF CALIBRATION: VOLUMETRIC

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Viscosity Flow Cup			
i. Ford Cup	Cup no. 1 (10 cSt to 35 cSt)	0.07 cSt	Calibrated using Standard Solution and Stop Watch based on ASTM D 1200:2010(2014)
	Cup no. 2 (25 cSt to 120 cSt)	0.2 cSt	
	Cup no. 3 (49 cSt to 220 cSt)	0.5 cSt	
	Cup no. 4 (70 cSt to 370 cSt)	0.6 cSt	
	Cup no. 5 (200 cSt to 1,200 cSt)	2 cSt	
ii. Zahn Cup	Cup no.1 (5 cSt to 60 cSt)	0.1 cSt	Calibrated using Standard Solution and Stop Watch based on ASTM D 4212:2016
	Cup no. 2 (20 cSt to 250 cSt)	0.5 cSt	
	Cup no. 3 (100 cSt to 800 cSt)	1.5 cSt	
	Cup no. 4 (200 cSt to 1,200 cSt)	2 cSt	
	Cup no. 5 (400 cSt to 1,800 cSt)	3 cSt	
Hydrometer	0.600 g/ml to 1.500 g/ml	0.7 mg/ml	Compare using Hydrometer based on BS 718:1991

Signatories:

1. **Seah Leong Ho**
2. **Kayalvili a/p Munusamy**

SCOPE OF CALIBRATION: ELECTRICAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Tachometer (Non-Contact)	0 rpm to 1,000 rpm	1.1 rpm	Calibrated using Tachometer Calibrator and Tachometer based on ASTM F2046:2006
	1,000 rpm to 10,000 rpm	2.3 rpm	
	10,000 rpm to 20,000 rpm	4.2 rpm	
Tachometer (Contact)	0 rpm to 1,000 rpm	1.1 rpm	
	1,000 rpm to 10,000 rpm	2.3 rpm	

Signatory:

1. **Seah Leong Ho**

SCOPE OF CALIBRATION: ELECTRICAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Measuring Instruments (DC & Low Frequency)			
1. DC Voltage	0 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 1000 V	8.5 µV/V + 0.46 µV 5.6 µV/V + 0.91 µV 3.7 µV/V + 5.9 µV 3.9 µV/V + 6.3 µV 5.6 µV/V + 59 µV 7.2 µV/V + 0.64 mV	Fluke 5720A
	1 kV to 10 kV	3.0 mV/V	TOS 5101, Fluke 45 & JRL KV-25
2. AC Voltage	0 to 1100 V	See Matrix A	Fluke 5720A & Wavetek 9100
3. Wideband AC Voltage	<u>1 kHz</u> 1.1 mV (-46 dBm) 3.0 mV (-37 dBm) 11 mV (-26 dBm) 33 mV (-17 dBm) 110 mV (-6.2 dBm) 330 mV (-3.4 dBm) 1.1 V (14 dBm) 3.5 V (24 dBm)	 8.0 mV/V 7.0 mV/V 7.0 mV/V 6.0 mV/V 6.0 mV/V 5.0 mV/V 5.0 mV/V 4.0 mV/V	Fluke 5720A
4. DC Current	-300 µA to -220 µA	0.14 m/A/A	Wavetek 9100
	-220 µA to 220 µA -2.2 mA to 2.2 mA -22 mA to 22 mA -220 mA to 220 mA -2.2 A to 2.2 A	70 µA/A 39 µA/A 37 µA/A 49 µA/A 86 µA/A	Fluke 5720A
	-20 A to -10 A -10 A to -3 A 3 A to 10 A 10 A to 20 A	0.55 mA/A 0.55 mA/A 0.55 mA/A 0.55 mA/A	Wavetek 9100
	20 A to 30 A	2.0 mA/A	Yokogawa 2552 & Yokogawa 2561
5. DC Current Clamp	10 A to 16.5 A 16.5 A to 150 A 150 A to 1000 A	2.8 mA/A + 3.6 mA 2.9 mA/A + 19 mA 3.2 mA/A + 17 mA	Fluke 5522A & 50-Turn Coil

SCOPE OF CALIBRATION: ELECTRICAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Measuring Instruments (DC & Low Frequency)			
6. AC Current	0 to 50 A	See Matrix B	Fluke 5720A, Wavetek 9100 & Yokogawa 2558
7. AC Current Clamp	45 Hz to 65 Hz		
	10 A to 16.5 A	3.3 mA/A + 5.0 mA	Fluke 5522A & 50-Turn Coil
	16.5 A to 150 A	3.5 mA/A + 32 mA	
	150 A to 1000 A	3.5 mA/A + 0.12 A	
	65 Hz to 440 Hz		
	10 A to 16.5 A	9.3 mA/A + 5.2 mA	
	16.5 A to 150 A	9.8 mA/A + 25 mA	
8. Resistance			
a) Fixed Resistance	0 Ω	10 μΩ/Ω	YEW 2792
	1 mΩ	0.20 mΩ/Ω	
	10 mΩ	0.10 mΩ/Ω	
	1 Ω	95 μΩ/Ω	Fluke 5720A
	10 Ω	23 μΩ/Ω	
	100 Ω	10 μΩ/Ω	
	1 kΩ	8.5 μΩ/Ω	
	10 kΩ	8.5 μΩ/Ω	
	100 kΩ	11 μΩ/Ω	
	1 MΩ	20 μΩ/Ω	
	10 MΩ	40 μΩ/Ω	
	100 MΩ	0.10 mΩ/Ω	
	1.9 Ω	95 μΩ/Ω	
	19 Ω	23 μΩ/Ω	
	190 Ω	10 μΩ/Ω	
	1.9 kΩ	8.5 μΩ/Ω	
	19 kΩ	8.5 μΩ/Ω	
	190 kΩ	11 μΩ/Ω	
	1.9 MΩ	21 μΩ/Ω	
	19 MΩ	50 μΩ/Ω	
b) Variable Resistance	0 to 40 Ω	0.25 mΩ/Ω	Wavetek 9100
	40 Ω to 400 Ω	0.25 mΩ/Ω	
	400 Ω to 4 kΩ	0.15 mΩ/Ω	
	4 kΩ to 40 kΩ	0.20 mΩ/Ω	
	40 kΩ to 400 kΩ	0.20 mΩ/Ω	
	400 kΩ to 4 MΩ	0.50 mΩ/Ω	
	4 MΩ to 40 MΩ	1.5 mΩ/Ω	
	40 MΩ to 400 MΩ	2.6 mΩ/Ω	

SCOPE OF CALIBRATION: ELECTRICAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Measuring Instruments (DC & Low Frequency)			
8. Resistance			
c) Earth Resistance	0.1 Ω to 1 kΩ 1 kΩ to 100 kΩ	0.10 mΩ/Ω 1.0 mΩ/Ω	Yokogawa 2793
d) LCR Resistance	1 Ω to 10 Ω 10 Ω to 100 Ω 100 Ω to 1 kΩ 1 kΩ to 10 kΩ 10 kΩ to 100 kΩ 100 kΩ to 1 MΩ	0.10 mΩ/Ω 0.10 mΩ/Ω 0.10 mΩ/Ω 0.50 mΩ/Ω 0.50 mΩ/Ω 0.50 mΩ/Ω	Yokogawa 2793
e) Insulation Resistance	100 kΩ to 10 MΩ 10 MΩ to 100 MΩ 100 MΩ to 1 GΩ 1 GΩ to 10 GΩ 10 GΩ to 100 GΩ 100 GΩ to 1 TΩ	2.0 mΩ/Ω 2.0 mΩ/Ω 1.0 mΩ/Ω 2.0 mΩ/Ω 5.0 mΩ/Ω 5.0 mΩ/Ω	Yokogawa 2793 & IET HRRS-5kV
f) High Current Resistance			
at 200 A	50 µΩ 100 µΩ 150 µΩ 200 µΩ	0.79 µΩ 0.45 µΩ 0.20 µΩ 1.1 µΩ	Time Elect. 5070
at 100 A	0.5 mΩ 1.0 mΩ 1.5 mΩ 2.0 mΩ	1.4 µΩ 1.0 µΩ 1.7 µΩ 2.4 µΩ	
at 30 A	5 mΩ 10 mΩ 15 mΩ 20 mΩ	11 µΩ 8.6 µΩ 11 µΩ 8.2 µΩ	
at 10 A	50 mΩ 100 mΩ 150 mΩ 200 mΩ	79 µΩ 80 µΩ 81 µΩ 83 µΩ	

SCOPE OF CALIBRATION: ELECTRICAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Measuring Instruments (DC & Low Frequency)			
9. Capacitance a) Variable Capacitance	0.5 nf to 4 nF 4 nF to 40 nF 40 nF to 400 nF 400 nF to 4 µF 4 µF to 40 µF 40 µF to 400 µF 400 µF to 4 mF 4 mF to 40 mF	3.4 mF/F 3.0 mF/F 3.0 mF/F 4.0 mF/F 5.0 mF/F 5.0 mF/F 5.0 mF/F 10 mF/F	Wavetek 9100
b) LCR Capacitance 1 kHz	1 pF to 10 pF 10 pF to 100 pF 100 pF to 1 nF 1 nF to 10 nF 10 nF to 100 nF 100 nF to 1 µF 1 µF to 10 µF 10 µF to 100 µF 100 µF to 1 mF	0.50 mF/F 0.50 mF/F 0.50 mF/F 0.50 mF/F 0.50 mF/F 0.50 mF/F 0.20 mF/F 0.40 mF/F 4.0 mF/F	IET 1413, SC-1000, IET SC-100 & SC-10
10. Inductance 1 kHz	100 µH to 1 mH 1 mH to 10 mH 10 mH to 100 mH 100 mH to 1 H 1 H to 10 H	20 mH/H 20 mH/H 20 mH/H 8.0 mH/H 8.0 mH/H	IET 1491-G
Measuring Instruments (Time & Frequency)			
11. Time	10 s to 60 s 60 s to 300 s 300 s to 600 s 600 s to 900 s 900 s to 1800 s 0.5 h to 1 h 1 h to 3 h	50 ms 60 ms 60 ms 60 ms 60 ms 90 ms 0.10 s	Pendulum 6689, HP 8662 & HP 53132A
12. RF Power	3 µW to 100 mW (-25 dBm to 20 dBm)	3.0 mW/W	HP 11683A, HP 432A, HP 478A & HP 34401A
13. FM Modulation Wow & Flutter	0 to 3 kHz	3.0 %	Minato 3101 & HP 8903E

SCOPE OF CALIBRATION: ELECTRICAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Measuring Instruments (Time & Frequency)			
14. Oscilloscope i) Vertical Deflection a) DC Voltage Load Impedance 1 MΩ	± (888 µV to 222.4 V)	0.25 mV/V	Wavetek 9500
b) Square Voltage Load Impedance 1 MΩ	35.52 μV_{pp} to 999.9 μV_{pp} 1 mV_{pp} to 21 mV_{pp} 21.001mV_{pp} to 556mV_{pp} 556.01 mV_{pp} to 210V_{pp}	10 mV_{pp}/V_{pp} 1.0 mV_{pp}/V_{pp} 1.0 mV_{pp}/V_{pp} 0.50 mV_{pp}/V_{pp}	
50 Ω	35.52 μV_{pp} to 999.9 μV_{pp} 1 mV_{pp} to 21 mV_{pp} 21.001mV_{pp} to 556mV_{pp} 556.01 mV_{pp} to 5.56V_{pp}	10 mV_{pp}/V_{pp} 1.0 mV_{pp}/V_{pp} 1.0 mV_{pp}/V_{pp} 0.50 mV_{pp}/V_{pp}	
ii) Horizontal Deflection a) Low Edge Load Impedance 50 Ω / 1 MΩ	4.44 mV_{pp} to 3.31 V_{pp} (Rise&Fall Time : 500ps)	30 mV_{pp}/V_{pp}	
b) High Edge Load Impedance 50 Ω	888 mV_{pp} to 5.56 V_{pp} (Rise&Fall Time : 100ns)	30 mV_{pp}/V_{pp}	
1 MΩ	888 mV_{pp} to 100 V_{pp} (Rise&Fall Time : 150ns)	30 mV_{pp}/V_{pp}	
c) Fast Edge Load Impedance 50 Ω	100 V_{pp} to 210 V_{pp} (Rise&Fall Time : 200ns)	30 mV_{pp}/V_{pp}	
	4.44 mV_{pp} to 3.1 V_{pp} (Rise&Fall Time : 150ps)	30 mV_{pp}/V_{pp}	
d) Time Markers Sine (50 Ω/1 MΩ)	450.5 ps to 909.09 ps 909.1 ps to 9.009 ns	0.25 µs/s 0.25 µs/s	
Square (50 Ω/1 MΩ)	9.0091 ns to 55 s	0.25 µs/s	

SCOPE OF CALIBRATION: ELECTRICAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Measuring Instruments (Time & Frequency)			
14. Oscilloscope ii) Horizontal Deflection a) Sine Voltage Load Impedance 50 Ω / 1 MΩ	<u>4.44 mV_{pp} to 5.56 V_{pp}</u> 50 Hz to 10 MHz 10 MHz to 100 MHz 100 MHz to 550 MHz <u>4.44 mV_{pp} to 3.336 V_{pp}</u> 550 MHz to 1.1 GHz	 15 mV_{pp}/V_{pp} 15 mV_{pp}/V_{pp} 30 mV_{pp}/V_{pp} 40 mV_{pp}/V_{pp}	Wavetek 9500
iii) Auxiliary a) DC Current	± (88.8 µA to 111.2 mA)	2.5 mA/A	
b) Square Current	88.8 μA_{pp} to 111.2 mA_{pp}	2.5 mA_{pp}/A_{pp}	
c) Resistance	50 kΩ to 12 MΩ 800 kΩ to 1.2 MΩ	5.0 mΩ/Ω 1.0 mΩ/Ω	
d) Capacitance	1 pF to 35 pF 35 pF to 95 pF	20 mF/F 30 mF/F	
15. Frequency	0.5 Hz to 10 MHz	25 µHz /Hz	Wavetek 9100

SCOPE OF CALIBRATION: ELECTRICAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Generating Instruments (DC & Low Frequency)			
1. DC Voltage	0 to 200 mV 200 mV to 2 V 2 V to 20 V 20 V to 200 V 200 V to 1000 V	5.6 µV/V + 0.12 µV 3.9 µV/V + 0.58 µV 3.9 µV/V + 5.6 µV 6.3 µV/V + 50 µV 6.1 µV/V + 0.68 mV	Fluke 8508A
	0.5 kV to 10 kV	5.0 mV/V	Kikusui 149-10A
	10 kV to 25 kV	2.4 mV/V	JRL KV-25 & Fluke 45
	25 kV to 100 kV	1.5 mV/V	JRL HV-100 & Fluke 45
2. AC Voltage	0 to 50 kV	See Matrix C	Fluke 5790A, Kikusui 149-10A, JRL HV-100 & HP 34401A
3. DC Current	0 to 200 µA 200 µA to 2 mA 2 mA to 20 mA 20 mA to 200 mA 200 mA to 2A	13 µA/A + 0.64 nA 13 µA/A + 6.4 nA 15 µA/A + 63 nA 54 µA/A + 0.98 µA 0.21 mA/A + 18 µA	Fluke 8508A
	-20 A to 20 A -100 A to 100 A	0.20 mA/A 0.50 mA/A	Valhalla 2575A & HP 34401A
4. AC Current	0 to 100 A	See Matrix D	Wavetek 1281, Valhalla 2575A & HP 34401A
5. Resistance	0 to 2 Ω 2 Ω to 20 Ω 20 Ω to 200 Ω 200 Ω to 2 kΩ 2 kΩ to 20 kΩ 20 kΩ to 200 kΩ 200 kΩ to 2 MΩ 2 MΩ to 20 MΩ 20 MΩ to 100 MΩ	7.3 µΩ/Ω + 55 µΩ 9.4 µΩ/Ω + 45 µΩ 9.0 µΩ/Ω + 62 µΩ 9.1 µΩ/Ω + 0.58 mΩ 9.1 µΩ/Ω + 5.8 mΩ 9.1 µΩ/Ω + 58 mΩ 10 µΩ/Ω + 1.1 Ω 23 µΩ/Ω + 0.11 kΩ 0.14 mΩ/Ω + 11 kΩ	Fluke 8508A

SCOPE OF CALIBRATION: ELECTRICAL

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Generating Instruments (DC & Low Frequency)			
6. Capacitance 1 kHz	 1 nF to 10 nF 10 nF to 100 nF 100 nF to 1 µF	 0.50 mF/F 0.50 mF/F 0.50 mF/F	 GW LCR-819
7. Inductance 1 kHz	 100 µH to 1 mH 1 mH to 10 mH 10 mH to 100 mH	 3.0 mH/H 3.0 mH/H 3.0 mH/H	 GW LCR-819
Generating Instruments (Time & Frequency)			
8. Frequency	0.1 Hz to 3 GHz	0.2 µHz/Hz	HP 53132A
9. Time	0.33 ns to 10 s	0.20 µs/s	HP 53132A

Signatories:

1. **Seah Leong Ho**
2. **Chin Inn Nkot**
3. **Shah Zulkifli Nor Bin Arshad**

SCOPE OF CALIBRATION: ELECTRICAL

SITE: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Measuring Instruments (DC & Low Frequency)			
1. DC Voltage	± (0 to 300 mV) ± (300 mV to 3 V) ± (3 V to 30 V) ± (30 V to 300 V) ± (300 V to 1000 V)	0.10 mV/V 0.10 mV/V 0.10 mV/V 0.10 mV/V 0.10 mV/V	Wavetek 9100
2. AC Voltage	0 to 1000 V	See Matrix E	Wavetek 9100
3. DC Current	± (0 to 300 µA) ± (300 µA to 3 mA) ± (3 mA to 30 mA) ± (30 mA to 300 mA) ± (300 mA to 3 A) ± (3 A to 10 A) ± (10 A to 20 A)	0.20 mA/A 0.20 mA/A 0.20 mA/A 0.20 mA/A 0.60 mA/A 0.60 mA/A 0.60 mA/A	Wavetek 9100
4. DC Current Clamp a) X 10 Coil	3.2 A to 32 A 32 A to 105 A 105 A to 200 A	3.0 mA/A 3.0 mA/A 3.0 mA/A	Wavetek 9100
b) X 50 Coil	16 A to 160 A 160 A to 525 A 525 A to 1000 A	3.0 mA/A 3.0 mA/A 3.0 mA/A	
5. AC Current	0 to 20 A	See Matrix F	Wavetek 9100
6. AC Current Clamp a) X 10 Coil	<u>3 A to 30 A</u> 10 Hz to 100 Hz 100 Hz to 440 Hz <u>30 A to 200 A</u> 10 Hz to 100 Hz 100 Hz to 440 Hz	 5.0 mA/A 10 mA/A 5.0 mA/A 10 mA/A	Wavetek 9100
b) X 50 Coil	<u>16 A to 160 A</u> 10 Hz to 100 Hz <u>160 A to 1000 A</u> 10 Hz to 100 Hz	 5.0 mA/A 5.0 mA/A	

SCOPE OF CALIBRATION: ELECTRICAL

SITE: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Measuring Instruments (DC & Low Frequency)			
7. Resistance			
a) Variable Resistance	0.1 Ω to 40 Ω	1.0 mΩ/Ω	Wavetek 9100
	40 Ω to 400 Ω	0.40 mΩ/Ω	
	400 Ω to 4 kΩ	0.40 mΩ/Ω	
	4 kΩ to 40 kΩ	0.30 mΩ/Ω	
	40 kΩ to 400 kΩ	0.30 mΩ/Ω	
	400 kΩ to 4 MΩ	0.50 mΩ/Ω	
	4 MΩ to 40 MΩ	2.0 mΩ/Ω	
	40 MΩ to 400 MΩ	3.0 mΩ/Ω	
b) LCR Resistance	1 Ω to 10 Ω	1.0 mΩ/Ω	Yokogawa 2793
	10 Ω to 100 Ω	1.0 mΩ/Ω	
	100 Ω to 1 kΩ	1.0 mΩ/Ω	
	1 kΩ to 10 kΩ	1.0 mΩ/Ω	
	10 kΩ to 100 kΩ	1.0 mΩ/Ω	
	100 kΩ to 1 MΩ	1.0 mΩ/Ω	
c) Insulation Resistance	10 MΩ to 100 MΩ	5.0 mΩ/Ω	Yokogawa 2793 & IET HRRS-5kV
	100 MΩ to 1 GΩ	5.0 mΩ/Ω	
	1 GΩ to 10 GΩ	5.0 mΩ/Ω	
	10 GΩ to 100 GΩ	10 mΩ/Ω	
	100 GΩ to 1 TΩ	10 mΩ/Ω	
8. Capacitance			
a) Variable Capacitance	0.5 nF to 4 nF	3.0 mF/F	Wavetek 9100
	4 nF to 40 nF	3.0 mF/F	
	40 nF to 400 nF	3.0 mF/F	
	400 nF to 4µF	4.0 mF/F	
	4 µF to 40 µF	10 mF/F	
	40 µF to 400 µF	10 mF/F	
	400 µF to 4 mF	10 mF/F	
	4 mF to 40 mF	10 mF/F	
b) LCR Capacitance 1 kHz	1 pF to 10 pF	1.0 mF/F	IET 1413, IET 1412-BC, IET SC-100, IET SC-100 & IET SC-1000
	10 pF to 100 pF	1.0 mF/F	
	100 pF to 1 nF	1.0 mF/F	
	1 nF to 10 nF	1.0 mF/F	
	10 nF to 100 nF	1.0 mF/F	
	100 nF to 1 µF	1.0 mF/F	
	1 µF to 10 µF	1.0 mF/F	
	10 µF to 100 µF	1.0 mF/F	
	100 µF to 1 mF	10 mF/F	

SCOPE OF CALIBRATION: ELECTRICAL

SITE: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Measuring Instruments (DC & Low Frequency)			
9. Inductance 1 kHz	100 µH to 1 mH 1 mH to 10 mH 10 mH to 100 mH 100 mH to 1 H 1 H to 10 H	30 mH/H 30 mH/H 30 mH/H 10 mH/H 10 mH/H	IET 1491-D/G
10. Frequency	0.5 Hz to 10 MHz	25 µHz/Hz	Wavetek 9100
Measuring Instruments (Time & Frequency)			
11. Oscilloscope i) Vertical Deflection a) Square Wave 50 Ω	4.44 mV_{pp} to 3.34 V_{pp}	3.0 mV/V_{pp}	Wavetek 9100
1 MΩ	4.44 mV_{pp} to 133.44 V_{pp}	3.0 $mV/_{Vpp}$	
b) DC Level 50 Ω	±(4.44 mV to 2.78 V)	3.0 mV/V	
1 MΩ	±(4.44 mV to 133.44 V)	3.0 mV/V	
ii) Horizontal Deflection a. Time Markers 50 Ω	4 ns/div to 5.5 s/div	25 µs/s	
b. Edge Response (Rise/Fall Time) 50 Ω load	< 1 ns	25 µs/s	
1 MΩ	< 100 ns	25 µs/s	
c. Bandwidth 50 Ω	50 kHz to 100 MHz 100 MHz to 250 MHz	2.0 mHz/Hz 4.0 mHz/Hz	
1 MΩ	10 Hz to 49.999 kHz	3.0 mHz/Hz	

SCOPE OF CALIBRATION: ELECTRICAL

SITE: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Generating Instruments (DC & Low Frequency)			
1. DC Voltage	±(0 to100 mV) ±(100 mV to 1 V) ±(1 V to 10 V) ±(10 V to 100 V) ±(100 V to 1000 V)	0.10 mV/V 0.10 mV/V 0.10 mV/V 0.10 mV/V 0.10 mV/V	HP 34401A
	0.2 kV to 5 kV 5 kV to 10 kV	10 mV/V 10 mV/V	Kikusui 149-10A
2. AC Voltage	0.5 kV to 10 kV 50 Hz to 60 Hz	15 mV/V	Kikusui 149-10A
3. DC Current	±(0 to 10 mA) ±(10 mA to 100 mA) ±(100 mA to 1 A) ±(1 A to 3 A)	1.0 mA/A 1.0 mA/A 2.0 mA/A 2.0 mA/A	HP 34401A

Signatories:

1. **Seah Leong Ho**
2. **Chin Inn Nkot**

SCOPE OF CALIBRATION: ELECTRICAL

PERMANENT & SITE CALIBRATION: CATEGORY I

MATRIX A TABLE (AC Voltage Measuring Instruments)

i) Generated by using Fluke 5720A

Voltage Range	Frequency								
	15 Hz to 50 Hz	20 Hz to 40 Hz	40 Hz to 20 kHz	50 Hz to 1 kHz	20 kHz to 50 kHz	50 kHz to 100 kHz	100 kHz to 300 kHz	300 kHz to 500 kHz	500 kHz to 1 MHz
0 mV to 2.2 mV	-	-	0.20 mV/V	-	0.50 mV/V	-	-	-	-
2.2 mV to 22 mV	-	0.28 mV/V	0.28 mV/V	-	0.40 mV/V	0.75 mV/V	1.5 mV/V	2.3 mV/V	3.6 mV/V
22 mV to 220 mV	-	0.12 mV/V	0.11 mV/V	-	0.23 mV/V	0.54 mV/V	0.99 mV/V	1.5 mV/V	2.9 mV/V
220 mV to 2.2 V	-	0.10 mV/V	50 µV/V	-	80 µV/V	0.12 mV/V	0.46 mV/V	1.1 mV/V	1.8 mV/V
2.2 V to 22 V	-	97 µV/V	48 µV/V	-	80 µV/V	0.11 mV/V	0.30 mV/V	1.1 mV/V	1.7 mV/V
22 V to 220 V	-	90 µV/V	52 µV/V	-	80 µV/V	0.15 mV/V	0.90 mV/V	-	-
220 V to 1100 V	0.30 mV/V	-	-	70 µV/V	-	-	-	-	-

ii) Generated by using Wavetek 9100

Voltage Range	Frequency								
	1 kHz to 3 kHz	3 kHz to 10 kHz	10 kHz to 20 kHz	-	-	-	-	-	-
220 V to 1100 V	0.80 mV/V	0.80 mV/V	1.2 mV/V	-	-	-	-	-	-

MATRIX B TABLE (AC Current Measuring Instruments)

i) Generated by using Fluke 5720A

Current Range	Frequency			
	20 Hz to 1 kHz	40 Hz to 1 kHz	1 kHz to 5 kHz	5 kHz to 10 kHz
30 µA to 220 µA	-	0.16 mA/A	0.34 mA/A	1.4 mA/A
220 µA to 2.2 mA	-	0.14 mA/A	0.25 mA/A	1.4 mA/A
2.2 mA to 22 mA	-	0.13 mA/A	0.21 mA/A	1.2 mA/A
22 mA to 2.2 A	0.28 mA/A	-	0.49 mA/A	7.1 mA/A

ii) Generated by using Wavetek 9100

Current Range	Frequency			
	10 Hz to 3 kHz	3 kHz to 10 kHz	10 kHz to 30 kHz	-
0 µA to 30 µA	0.70 mA/A	1.0 mA/A	2.0 mA/A	-
3 A to 10 A	2.0 mA/A	5.0 mA/A	-	-
10 A to 20 A	2.0 mA/A	5.0 mA/A	-	-

iii) Generated by using Yokogawa 2558

Current Range	Frequency			
	50 Hz to 60 Hz	60 Hz to 400 Hz	-	-
20 A to 50 A	0.15 mA/A	0.15 mA/A	-	-

SCOPE OF CALIBRATION: ELECTRICAL

PERMANENT & SITE CALIBRATION: CATEGORY I

MATRIX C TABLE (AC Voltage Generating Instruments)

i) Measured by using Fluke 5790A			
Voltage Range	**Frequency**		
	45 Hz to 20 Hz	**20 kHz to 50 kHz**	**50 kHz to 100 kHz**
7 mV to 22 mV	0.12 mV/V + 1.6 µV	0.24 mV/V + 2.3 µV	0.35 mV/V + 2.9 µV
22 mV to 70 mV	78 µV/V + 1.8 µV	0.15 mV/V + 2.3 µV	0.29 mV/V + 2.9 µV
70 mV to 220 mV	49 µV/V + 1.7 µV	83 µV/V + 2.3 µV	0.18 mV/V + 2.8 µV
220 mV to 700 mV	44 µV/V + 1.7 µV	64 µV/V + 2.2 µV	96 µV/V + 2.8 µV
700 mV to 2.2 V	32 µV/V	59 µV/V	86 µV/V
2.2 V to 7 V	34 µV/V	61 µV/V	0.1 mV/V
7 V to 22 V	35 µV/V	60 µV/V	96 µV/V
22 V to 70 V	45 µV/V	72 µV/V	0.12 mV/V
70 V to 220 V	43 µV/V	87 µV/V	0.12 mV/V
220 V to 700 V	54 µV/V	-	-
700 V to 1000 V	49 µV/V	-	-
ii) Measured by using Kikusui 149-10A			
Voltage Range	**Frequency**		
	50 Hz to 60 Hz	**-**	**-**
0.5 kV to 10 kV	10 mv/V	-	-
iii) Measured by using JRL HV-100 & HP 34401A			
Voltage Range	**Frequency**		
	50 Hz to 60 Hz	**-**	**-**
10 kV to 25 kV	0.40 V/V	-	-
25 kV to 50 kV	0.80 V/V	-	-

MATRIX D TABLE (AC Current Generating Instruments)

i) Measured by using Fluke 8508A			
Current Range	**Frequency**		
	40 Hz to 2 kHz	**45 Hz to 10 kHz**	**2 kHz to 10 kHz**
0 to 200 µA	-	0.56 mA/A + 23 nA	-
200 µA to 2 mA	-	0.34 mA/A + 0.23 µA	-
2 mA to 20 mA	-	0.34 mA/A + 2.3 µA	-
20 mA to 200 mA	-	0.33 mA/A + 23 µA	-
200 mA to 2 A	0.70 mA/A + 0.23 mA	-	0.83 mA/A + 0.23 mA
ii) Measured by using Valhalla 2575A & HP 34401A			
Current Range	**Frequency**		
	50 Hz to 1 kHz	**1 kHz to 10 kHz**	**-**
2 A to 20 A	1.0 mA/A	5.0 mA/A	-
20 A to 100 A	1.0 mA/A	5.0 mA/A	-

SCOPE OF CALIBRATION: ELECTRICAL

PERMANENT & SITE CALIBRATION: CATEGORY I

MATRIX E TABLE (AC Voltage Measuring Instruments)

Generated by using Wavetek 9100						
Voltage Range	**Frequency**					
	10 Hz to 3 kHz	**3 kHz to 10 kHz**	**10 kHz to 30 kHz**	**30 kHz to 50 kHz**	**50 kHz to 100 kHz**	**-**
0 mV to 10 mV	1.0 mV/V	1.0 mV/V	1.0 mV/V	1.0 mV/V	5.0 mV/V	-
10 mV to 30 mV	1.0 mV/V	1.0 mV/V	1.0 mV/V	1.0 mV/V	5.0 mV/V	-
30 mV to 300 mV	1.0 mV/V	1.0 mV/V	1.0 mV/V	1.0 mV/V	5.0 mV/V	-
300 mV to 1.5 V	1.0 mV/V	1.0 mV/V	1.0 mV/V	1.0 mV/V	2.0 mV/V	-
1.5 V to 3 V	1.0 mV/V	1.0 mV/V	1.0 mV/V	1.0 mV/V	2.0 mV/V	-
3 V to 30 V	1.0 mV/V	1.0 mV/V	1.0 mV/V	2.0 mV/V	4.0 mV/V	-
30 V to 100 V	1.0 mV/V	1.0 mV/V	1.0 mV/V	2.0 mV/V	4.0 mV/V	-
Voltage Range	**Frequency**					
	40 Hz to 100 Hz	**100 Hz to 1 kHz**	**1 kHz to 3 kHz**	**3 kHz to 10 kHz**	**10 kHz to 20 kHz**	**20 kHz to 30 kHz**
100 V to 300 V	1.0 mV/V	1.0 mV/V	1.0 mV/V	1.0 mV/V	1.0 mV/V	2.0 mV/V
300 V to 750 V	1.0 mV/V	1.0 mV/V	1.0 mV/V	1.0 mV/V	1.0 mV/V	2.0 mV/V
750 V to 1000 V	1.0 mV/V	1.0 mV/V	1.0 mV/V	1.0 mV/V	2.0 mV/V	-

MATRIX F TABLE (AC Current Measuring Instruments)

Generated by using Wavetek 9100				
Current Range	**Frequency**			
	10 Hz to 3 kHz	**3 kHz to 10 kHz**	**10 kHz to 20 kHz**	**20 kHz to 30 kHz**
0 to 30 µA	1.0 mA/A	2.0 mA/A	3.0 mA/A	3.0 mA/A
30 µA to 300 µA	1.0 mA/A	2.0 mA/A	3.0 mA/A	3.0 mA/A
300 µA to 3 mA	1.0 mA/A	1.0 mA/A	2.0 mA/A	3.0 mA/A
3 mA to 30 mA	1.0 mA/A	1.0 mA/A	2.0 mA/A	3.0 mA/A
30 mA to 300 mA	1.0 mA/A	1.0 mA/A	2.0 mA/A	3.0 mA/A
300 mA to 3 A	2.0 mA/A	3.0 mA/A	2.0 mA/A	3.0 mA/A
3 A to 10 A	3.0 mA/A	10 mA/A	-	-
10 A to 20 A	3.0 mA/A	10 mA/A	-	-

SCOPE OF CALIBRATION: OPTICAL AND PHOTOMETRIC MEASUREMENTS

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Spectrophotometer (UV-Visible Range)			
a) Wavelength	240 nm to 645 nm	0.2 nm	Calibrated using Holmium perchlorate as standard based on ASTM E275:2008(2013) and ASTM E925:2009(2014)
b) Absorbance (230 nm to 640 nm)	0.2 to 1.0	0.006	Calibrated using Potassium Dichromate and Neutral Density Filter as standard based on ASTM E275:2008(2013) and ASTM E925:2009(2014)
Transmittance (Normal incidence)	240 nm to 780 nm	0.94 %	Calibrated using Agilent Cary 7000 Spectrophotometer based on ASTM D1746:2015 and ISO 9050:2003

Signatories:

1. **Seah Leong Ho**
2. **Teo Kok Siong**

SCOPE OF CALIBRATION: OPTICAL AND PHOTOMETRIC MEASUREMENTS

SITE: CATEGORY I

Instrument Calibrated/ Measurement Parameter	Range	Calibration and Measurement Capability Expressed as an Uncertainty(±)*	Remarks
Spectrophotometer (UV-Visible Range)			
a) Wavelength	240 nm to 645 nm	0.2 nm	Calibrated using Holmium perchlorate as standard based on ASTM E275:2008(2013) and ASTM E925:2009(2014)
b) Absorbance (230 nm to 640 nm)	0.2 to 1.0	0.006	Calibrated using Potassium Dichromate and Neutral Density Filter as standard based on ASTM E275:2008(2013) and ASTM E925:2009(2014

Signatories:

1. **Seah Leong Ho**
2. **Teo Kok Siong**