



**STANDARDS**  
MALAYSIA

# Certificate of Accreditation

No: SAMM 088

Accredited since: 14 September 1995

This is to certify that

SIRIM CALIBRATION SDN. BHD.  
SHAH ALAM, SELANGOR  
MALAYSIA



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for the current scope of accreditation

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Laboratories accredited under SAMM meet the requirements of MS ISO/IEC 17025. This Malaysian Standard is identical with ISO/IEC 17025 published by the International Organization for Standardization (ISO).



(SHAHARUL SADRI BIN ALWI)  
Director General  
Department of Standards Malaysia

Date of issue: 3 January 2023  
(Issue 2, 6 September 2017 replacement of  
SAMM 088 dated 3 January 2023)



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LABORATORY LOCATION:  
(PERMANENT LABORATORY)

SIRIM CALIBRATION SDN. BHD.  
(Company No.: 292201-P)  
LOT 12, 18 & 20, JALAN BEREMBAN 15/12  
SEKSYEN 15  
40200 SHAH ALAM, SELANGOR  
MALAYSIA

FIELDS OF CALIBRATION:

ELECTRICAL, ACOUSTIC & VIBRATION  
MEASUREMENT, PRESSURE, DIMENSIONAL, MASS  
AND MASS RELATED, TEMPERATURE

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

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

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

**SCOPE OF CALIBRATION: ELECTRICAL**

| Instrument Calibrated/<br>Measurement Parameter | Range                                        | Calibration and<br>Measurement<br>Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks     |
|-------------------------------------------------|----------------------------------------------|--------------------------------------------------------------------------------------------|-------------|
| 1. Measuring Instrument<br>DC VOLTAGE           | $\pm 220$ mV Range<br>$\pm$ (0 mV to 220 mV) | $7.5 \mu\text{V/V} + 0.4 \mu\text{V}$                                                      | Fluke 5730A |
|                                                 | $\pm 2.2$ V Range<br>$\pm$ (0 V to 2.2 V)    | $5 \mu\text{V/V} + 0.7 \mu\text{V}$                                                        |             |
|                                                 | $\pm 11$ V Range<br>$\pm$ (0 V to 11 V)      | $3.5 \mu\text{V/V} + 2.5 \mu\text{V}$                                                      |             |
|                                                 | $\pm 22$ V Range<br>$\pm$ (0 V to 22 V)      | $3.5 \mu\text{V/V} + 4 \mu\text{V}$                                                        |             |
|                                                 | $\pm 220$ V Range<br>$\pm$ (0 V to 220 V)    | $5 \mu\text{V/V} + 40 \mu\text{V}$                                                         |             |

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## SCOPE OF CALIBRATION: ELECTRICAL

| Instrument Calibrated/<br>Measurement Parameter   | Range                                                                                                                                                                                                                                                                                 | Calibration and<br>Measurement<br>Capability Expressed<br>as an Uncertainty ( $\pm$ ) *                                                                                             | Remarks      |
|---------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| 1. Measuring Instrument<br>Continue<br>DC VOLTAGE | $\pm 1100$ V Range<br>$\pm (100$ V to 1100 V)                                                                                                                                                                                                                                         | $6.5 \mu\text{V/V} + 0.4$ mV                                                                                                                                                        | Fluke 5730A  |
| AC VOLTAGE                                        | <u>2.2 mV to 220 V</u><br>(See Matrix A)                                                                                                                                                                                                                                              | (See Matrix A)                                                                                                                                                                      | Fluke 5730A  |
|                                                   | <u>1100 V Range (110 V to 1100 V)</u><br>15 Hz to 50 Hz<br>50 Hz to 1 kHz                                                                                                                                                                                                             | $360 \mu\text{V/V} + 20$ mV<br>$85 \mu\text{V/V} + 4$ mV                                                                                                                            | Fluke 5730A  |
|                                                   | <u>800 V to 1050 V</u><br>1 kHz to 3 kHz<br>3 kHz to 10 kHz<br>10 kHz to 20 kHz                                                                                                                                                                                                       | $0.8$ mV/V + 0.13 V<br>$0.8$ mV/V + 0.21 V<br>$1.2$ mV/V + 0.32 V                                                                                                                   | Wavetek 9100 |
| DC CURRENT                                        | $\pm 220 \mu\text{A}$ Range<br>$\pm (0 \mu\text{A}$ to 220 $\mu\text{A}$ )<br><br>$\pm 2.2$ mA Range<br>$\pm (0$ mA to 2.2 mA)<br><br>$\pm 22$ mA Range<br>$\pm (0$ mA to 22 mA)<br><br>$\pm 220$ mA Range<br>$\pm (0$ mA to 220 mA)<br><br>$\pm 2.2$ A Range<br>$\pm (0$ A to 2.2 A) | $40 \mu\text{A/A} + 6$ nA<br><br>$35 \mu\text{A/A} + 7$ nA<br><br>$35 \mu\text{A/A} + 40$ nA<br><br>$45 \mu\text{A/A} + 0.7 \mu\text{A}$<br><br>$80 \mu\text{A/A} + 12 \mu\text{A}$ | Fluke 5730A  |
|                                                   | $\pm 3.2$ A Range<br>$\pm (0.32$ A to 3.2 A)<br><br>$\pm 10.5$ A Range<br>$\pm (3.2$ A to 10.5 A)<br><br>$\pm 20$ A Range<br>$\pm (10.5$ A to 20 A)                                                                                                                                   | $0.6$ mA/A + 0.12 mA<br><br>$0.55$ mA/A + 0.94 mA<br><br>$0.55$ mA/A + 4.5 mA                                                                                                       | Wavetek 9100 |

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## SCOPE OF CALIBRATION: ELECTRICAL

| Instrument Calibrated/<br>Measurement<br>Parameter | Range                                                                                               | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks                                                 |
|----------------------------------------------------|-----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|---------------------------------------------------------|
| 1. Measuring Instrument<br>Continue<br>AC CURRENT  | <u>9 <math>\mu</math>A to 2.2 A</u><br>(See Matrix B)                                               | (See Matrix B)                                                                          | Fluke 5730A                                             |
|                                                    | <u>0.32 A to 3.2 A</u><br>10 Hz to 3 kHz<br>3 kHz to 10 kHz                                         | 1 mA/A + 0.48 mA<br>2.5 mA/A + 2.6 mA                                                   | Wavetek 9100                                            |
|                                                    | <u>3.2 A to 10.5 A</u><br>10 Hz to 3 kHz<br>3 kHz to 10 kHz                                         | 2 mA/A + 3 mA<br>5 mA/A + 10 mA                                                         |                                                         |
|                                                    | <u>10.5 A to 20 A</u><br>10 Hz to 3 kHz<br>3 kHz to 10 kHz                                          | 2 mA/A + 6.9 mA<br>5 mA/A + 23 mA                                                       |                                                         |
| Residual Current                                   | <u>3 mA to 3A</u><br>At Time interval up to 5 s<br>At Time interval <190 ms                         | 0.14 mA/A<br>0.3 mA/A                                                                   | For RCD Tester<br>Calibrator<br>(using Transmille 3200) |
| CAPACITANCE                                        | (See Matrix C)                                                                                      | (See Matrix C)                                                                          | Wavetek 9100                                            |
| Fixed Value                                        | <u>20 Hz to 1 MHz</u><br>1 pF, 10 pF, 100 pF, 1000 pF,<br>0.01 $\mu$ F, 0.1 $\mu$ F and 1.0 $\mu$ F | 1 mF/F                                                                                  | HP 1600A series                                         |
| INDUCTANCE<br>Fixed Value                          | <u>100 <math>\mu</math>H @ 1 kHz</u><br><u>(1, 10, 100) mH @ 1 kHz</u><br><u>1H @ 1 kHz</u>         | 2.5 mH/H<br>1 mH/H<br>1 mH/H                                                            | Ando RS-100 series                                      |

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## SCOPE OF CALIBRATION: ELECTRICAL

| Instrument Calibrated/<br>Measurement Parameter                  | Range                                                                                                                                                                                                                                                                                                                   | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) *                                                                                                                                                                                                                                                                                                                                                                                             | Remarks                                                           |
|------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| 1. Measuring Instrument<br>Continue<br>RESISTANCE<br>Fixed Value | 1 m $\Omega$<br>10 m $\Omega$<br>100 m $\Omega$<br>1 $\Omega$<br>1.9 $\Omega$<br>10 $\Omega$<br>19 $\Omega$<br>100 $\Omega$<br>190 $\Omega$<br>1 k $\Omega$<br>1.9 k $\Omega$<br>10 k $\Omega$<br>19 k $\Omega$<br>100 k $\Omega$<br>190 k $\Omega$<br>1 M $\Omega$<br>1.9 M $\Omega$<br>10 M $\Omega$<br>19 M $\Omega$ | 0.2 m $\Omega/\Omega$<br>0.1 m $\Omega/\Omega$<br>0.02 m $\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>95 $\mu\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>23 $\mu\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>10 $\mu\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>6.5 $\mu\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>6.5 $\mu\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>8.5 $\mu\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>18 $\mu\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>47 $\mu\Omega/\Omega$ | Fluke 5730A & Fluke<br>742A Series Resistance<br>Standard         |
|                                                                  | 100 M $\Omega$<br>1 G $\Omega$<br>10 G $\Omega$<br>100 G $\Omega$<br>1 T $\Omega$                                                                                                                                                                                                                                       | 0.1 m $\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>0.02 $\Omega/\Omega$<br>0.05 $\Omega/\Omega$<br>0.05 $\Omega/\Omega$                                                                                                                                                                                                                                                                                                                                                               | Fluke 5730A<br>& Takeda Riken TR45<br>Series Standard<br>Resistor |
| POWER/ ENERGY<br>(DC)                                            | 1 kW to 20 kW<br>0.1 W to 1 kW                                                                                                                                                                                                                                                                                          | 0.7 mW/W<br>0.22 mW/W                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Fluke 5522A                                                       |
| POWER / ENERGY (AC),<br>(45 Hz to 65 Hz at PF=1)                 | 10 kW to 20 kW<br>1 W to 10 kW<br>0.1 W to 1 W                                                                                                                                                                                                                                                                          | 1 mW/W<br>0.9 mW/W<br>1 mW/W                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                   |

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## SCOPE OF CALIBRATION: ELECTRICAL

| Instrument Calibrated/<br>Measurement<br>Parameter                    | Range                                                                                                                                                                                                                                                                                                                                                                    | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) *                                                                                                                                                                                                                                                         | Remarks                                  |
|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| HIGH VOLTAGE<br>METER<br>DC Voltage<br><br>AC Voltage @<br>(50/60) Hz | 0.5 kV to 10 kV                                                                                                                                                                                                                                                                                                                                                          | 0.35 mV/V + 0.07 V                                                                                                                                                                                                                                                                                                                              | Vitretek (4700 & HVP 35)<br>and TOS 5101 |
|                                                                       |                                                                                                                                                                                                                                                                                                                                                                          | 1 mV/V + 0.2 V                                                                                                                                                                                                                                                                                                                                  |                                          |
| CLAMP METER<br>DC Current<br>10 – Turn Coil                           | $\pm 3.2$ A to 32 A<br>$\pm 32$ A to 105 A<br>$\pm 105$ A to 200 A                                                                                                                                                                                                                                                                                                       | 0.06 mA/A + 1.18 mA<br>0.55 mA/A + 9.4 mA<br>0.55 mA/A + 45 mA                                                                                                                                                                                                                                                                                  | Wavetek 9100 c/w<br>Current Coil         |
| 50 – Turn Coil                                                        | $\pm 16$ A to 160 A<br>$\pm 160$ A to 525 A<br>$\pm 525$ A to 1000 A                                                                                                                                                                                                                                                                                                     | 0.6 mA/A + 5.9 mA<br>0.55 mA/A + 47 mA<br>0.55 mA/A + 0.23 A                                                                                                                                                                                                                                                                                    |                                          |
| AC Current<br>10 – Turn Coil                                          | <u>3.2 A to 32 A</u><br>10 Hz to 100 Hz<br>100 Hz to 440 Hz<br><br><u>32 A to 200 A</u><br>10 Hz to 100 Hz<br>100 Hz to 440 Hz                                                                                                                                                                                                                                           | 2 mA/A + 5.5 mA<br>7.8 mA/A + 27 mA<br><br>2.1 mA/A + 90 mA<br>6.7 mA/A + 0.25 A                                                                                                                                                                                                                                                                |                                          |
| CLAMP METER<br>50 – Turn Coil                                         | <u>16 A to 160 A</u><br>10 Hz to 100 Hz<br><br><u>160 A to 1000 A</u><br>10 Hz to 100 Hz                                                                                                                                                                                                                                                                                 | 2 mA/A + 28 mA<br><br>2.1 mA/A + 0.45 A                                                                                                                                                                                                                                                                                                         | Wavetek 9100 c/w<br>Current Coil         |
| INSULATION<br>TESTER                                                  | (1 k $\Omega$ to 10 k $\Omega$ ) @ 10 V                                                                                                                                                                                                                                                                                                                                  | 26 $\mu\Omega/\Omega$ + 0.6 $\Omega$                                                                                                                                                                                                                                                                                                            | Biddle 726349                            |
|                                                                       | (10 k $\Omega$ to 100 k $\Omega$ ) @ 50 V<br>(0.1 M $\Omega$ to 1 M $\Omega$ ) @ 150 V<br>(1 M $\Omega$ to 10 M $\Omega$ ) @ 300 V<br>(10 M $\Omega$ to 100 M $\Omega$ ) @ 500 V<br>(0.1 G $\Omega$ to 1 G $\Omega$ ) @ 1000 V<br>(1 G $\Omega$ to 10 G $\Omega$ ) @ 5000 V<br>(10 G $\Omega$ to 100 G $\Omega$ ) @ 5000 V<br>(100 G $\Omega$ to 600 G $\Omega$ ) @ 5000 | 16 $\mu\Omega/\Omega$ + 0.47 $\Omega$<br>34 $\mu\Omega/\Omega$ + 0.68 k $\Omega$<br>5.1 $\mu\Omega/\Omega$ + 0.67 k $\Omega$<br>73 $\mu\Omega/\Omega$ + 5.5 k $\Omega$<br>73 $\mu\Omega/\Omega$ + 55 k $\Omega$<br>0.28 m $\Omega/\Omega$ + 0.7 M $\Omega$<br>4.1 m $\Omega/\Omega$ + 0.43 M $\Omega$<br>4.3 m $\Omega/\Omega$ + 4.1 M $\Omega$ | IET HRRS-Q-9-10k                         |

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## SCOPE OF CALIBRATION: ELECTRICAL

| Instrument Calibrated/<br>Measurement<br>Parameter          | Range                                                                                                           | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks                                            |
|-------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|----------------------------------------------------|
| 1. Measuring Instrument<br>Continue                         |                                                                                                                 |                                                                                         |                                                    |
| OSCILLOSCOPE<br>Vertical Deflection<br>DC Signal            | 0 V to $\pm 6.6$ V (50 $\Omega$ Load)<br>0 V to $\pm 130$ V (1 M $\Omega$ Load)                                 | 2.5 mV/V + 0.04 mV<br>0.5 mV/V + 0.04 mV                                                | Fluke 5500A SC600                                  |
| Vertical Deflection<br>Square Wave Signal                   | $\pm 1$ mVp-p to $\pm 6.6$ Vp-p<br>(50 $\Omega$ Load)<br>$\pm 1$ mVp-p to $\pm 130$ Vp-p<br>(1 M $\Omega$ Load) | 2.5 mVp-p/Vp-p +<br>0.04mVp-p<br><br>1 mVp-p/Vp-p + 0.04<br>mVp-p                       |                                                    |
| Horizontal Deflection<br>Time Markers<br>(50 $\Omega$ Load) | 2 ns/div to 20 ms/div<br>50 ms/div to 5 s/div                                                                   | 2.5 $\mu$ s/s<br>(25+(Output x 1000)) $\mu$ s/s                                         |                                                    |
| Rise time                                                   | $\leq 300$ ps                                                                                                   | +0 ns / -0.1 ns                                                                         |                                                    |
| Bandwidth Frequency                                         | 50 kHz to 600 MHz                                                                                               | 2.5 $\mu$ Hz/Hz                                                                         |                                                    |
| Bandwidth Amplitude                                         | 600 MHz to 40 GHz<br>(+11 dBm to -135 dBm)                                                                      | 7 nHz/Hz                                                                                | Agilent E8257D<br>Reference to SPIRENT<br>STR 4500 |
|                                                             | 50 kHz to 600 MHz                                                                                               | 0.03 Vp-p                                                                               | Fluke 5500A SC600                                  |
|                                                             | 600 MHz to 40 GHz<br>(+11 dBm to -135 dBm)                                                                      | 0.92 dBm                                                                                | Agilent E8257D                                     |

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## SCOPE OF CALIBRATION: ELECTRICAL

Matrix A  
AC Voltage Measurement

| Range  |                   | Frequency    |              |               |              |
|--------|-------------------|--------------|--------------|---------------|--------------|
|        |                   | Hz           |              | kHz           |              |
|        |                   | 10 to 20     | 20 to 40     | 0.04 to 20    | 20 to 50     |
| 2.2 mV | 0.22 mV to 2.2 mV | 0.24 + 0.004 | 0.09 + 0.004 | 0.08 + 0.004  | 0.2 + 0.004  |
| 22 mV  | 2.2 mV to 22 mV   | 0.24 + 0.004 | 0.09 + 0.004 | 0.08 + 0.004  | 0.2 + 0.004  |
| 220 mV | 22 mV to 220 mV   | 0.24 + 0.012 | 0.09 + 0.007 | 0.057 + 0.007 | 0.12 + 0.007 |
| 2.2 V  | 0.22 V to 2.2 V   | 0.24 + 0.04  | 0.09 + 0.015 | 0.042 + 0.008 | 0.067 + 0.01 |
| 22 V   | 2.2 V to 22 V     | 0.24 + 0.4   | 0.09 + 0.15  | 0.042 + 0.05  | 0.067 + 0.1  |
| 220 V  | 22 V to 220 V     | 0.24 + 4     | 0.09 + 1.5   | 0.052 + 0.6   | 0.08 + 1     |

| Range  |                   | Frequency    |              |             |             |
|--------|-------------------|--------------|--------------|-------------|-------------|
|        |                   | MHz          |              |             |             |
|        |                   | 0.05 to 0.1  | 0.1 to 0.3   | 0.3 to 0.5  | 0.5 to 1    |
| 2.2 mV | 0.22 mV to 2.2 mV | 0.5 + 0.005  | 1.05 + 0.01  | 1.4 + 0.02  | 2.7 + 0.02  |
| 22 mV  | 2.2 mV to 22 mV   | 0.5 + 0.005  | 1.05 + 0.01  | 1.4 + 0.02  | 2.7 + 0.02  |
| 220 mV | 22 mV to 220 mV   | 0.31 + 0.017 | 0.655 + 0.03 | 1.4 + 0.025 | 2.7 + 0.045 |
| 2.2 V  | 0.22 V to 2.2 V   | 0.085 + 0.03 | 0.336 + 0.08 | 1 + 0.2     | 1.7 + 0.3   |
| 22 V   | 2.2 V to 22 V     | 0.085 + 0.2  | 0.254 + 0.6  | 1 + 2       | 1.5 + 3.2   |
| 220 V  | 22 V to 220 V     | 0.15 + 2.5   | 0.9 + 16     | 4.4 + 40    | 8 + 80      |

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

Matrix B  
AC Current Measurement

| Range                    | Frequency (kHz) |              |               |              |             |
|--------------------------|-----------------|--------------|---------------|--------------|-------------|
|                          | 0.01 to 0.02    | 0.02 to 0.04 | 0.04 to 1     | 1 to 5       | 5 to 10     |
| 9 $\mu$ A to 220 $\mu$ A | 0.25 + 0.016    | 0.16 + 0.01  | 0.103 + 0.008 | 0.28 + 0.012 | 1.1 + 0.065 |
| 0.22 mA to 2.2 mA        | 0.25 + 0.04     | 0.16 + 0.035 | 0.103 + 0.035 | 0.2 + 0.11   | 1.1 + 0.65  |
| 2.2 mA to 22 mA          | 0.25 + 0.4      | 0.16 + 0.35  | 0.103 + 0.35  | 0.2 + 0.55   | 1.1 + 5     |
| 22 mA to 220 mA          | 0.25 + 4        | 0.16 + 3.5   | 0.103 + 2.5   | 0.2 + 3.5    | 1.1 + 10    |
| 0.22 A to 2.2 A          | Frequency (kHz) |              |               |              |             |
|                          |                 |              | 0.02 to 1     | 1 to 5       | 5 to 10     |
|                          |                 |              | 0.244 + 35    | 0.45 + 80    | 7 + 160     |

The expanded uncertainties given in this table are expressed in mA/A +  $\mu$ A



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**SCOPE OF CALIBRATION: ELECTRICAL**Matrix C  
Capacitance Measurement

| Range                     | Frequency             |                        |
|---------------------------|-----------------------|------------------------|
|                           | $\leq 350$ Hz         | 350 Hz to 1.5 kHz      |
| 0.5 nF to 4 nF            | 3 mF/F + 15 pF        | 6 mF/F + 0.03 nF       |
| 4 nF to 40 nF             | 3 mF/F + 30 pF        | 6 mF/F + 0.06 nF       |
| 40 nF to 400 nF           | 3 mF/F + 0.16 nF      | 6 mF/F + 0.32 nF       |
| 400 nF to 4 $\mu$ F       | 4 mF/F + 1.6 nF       | 8 mF/F + 3.2 nF        |
|                           | 5 mF/F + 16 nF        | 10 mF/F + 32 nF        |
| 40 $\mu$ F to 400 $\mu$ F | 5 mF/F + 0.16 $\mu$ F | 10 mF/F + 0.32 $\mu$ F |
| 400 $\mu$ F to 4 mF       | 5 mF/F + 1.6 $\mu$ F  | 10 mF/F + 3.2 $\mu$ F  |
| 4 mF to 40 mF             | 10 mF/F + 0.06 mF     | 20 mF/F + 0.12 mF      |
|                           |                       |                        |

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## SCOPE OF CALIBRATION: ELECTRICAL

| Instrument Calibrated/<br>Measurement<br>Parameter | Range                                                            | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks                                            |
|----------------------------------------------------|------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------|
| 2. Generating Instrument<br>DC VOLTAGE             | $\pm 100$ mV Range<br>$\pm (100 \mu\text{V to } 120 \text{ mV})$ | $5 \mu\text{V/V} + 0.3 \mu\text{V}$                                                    | HP 3458A Opt. 002                                  |
|                                                    | $\pm 1$ V Range<br>$\pm (100 \text{ mV to } 1.2 \text{ V})$      | $4 \mu\text{V/V} + 0.3 \mu\text{V}$                                                    |                                                    |
|                                                    | $\pm 10$ V Range<br>$\pm (1 \text{ V to } 12 \text{ V})$         | $4 \mu\text{V/V} + 0.5 \mu\text{V}$                                                    |                                                    |
|                                                    | $\pm 100$ V Range<br>$\pm (10 \text{ V to } 120 \text{ V})$      | $6 \mu\text{V/V} + 0.03 \text{ mV}$                                                    |                                                    |
|                                                    | $\pm 1000$ V Range<br>$\pm (100 \text{ V to } 1050 \text{ V})$   | $6 \mu\text{V/V} + 0.1 \text{ mV}$                                                     |                                                    |
| 2. Generating Instrument<br>Continue<br>DC VOLTAGE | 200 mV                                                           | $2.7 \mu\text{V/V} + 0.5 \mu\text{V}$                                                  | Fluke 8508A with<br>Guildline 7520 &<br>Fluke 732B |
|                                                    | 2 V                                                              | $2.7 \mu\text{V/V} + 0.2 \mu\text{V}$                                                  |                                                    |
|                                                    | 20 V                                                             | $2.7 \mu\text{V/V} + 0.2 \mu\text{V}$                                                  |                                                    |
|                                                    | 200 V                                                            | $4.0 \mu\text{V/V} + 0.2 \mu\text{V}$                                                  |                                                    |
|                                                    | 1000 V                                                           | $4.0 \mu\text{V/V} + 0.2 \mu\text{V}$                                                  |                                                    |

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## SCOPE OF CALIBRATION: ELECTRICAL

| Instrument Calibrated/<br>Measurement<br>Parameter | Range                             | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks                                                   |
|----------------------------------------------------|-----------------------------------|-----------------------------------------------------------------------------------------|-----------------------------------------------------------|
| AC VOLTAGE                                         | 2.2 mV to 1000V<br>(See Matrix D) | (See Matrix D)                                                                          | Fluke 5790A                                               |
|                                                    | 10 mV to 700V<br>(See Matrix E)   | (See Matrix E)                                                                          | HP 3458A Opt. 002                                         |
| DC CURRENT                                         | 200 $\mu$ A                       | 6.5 $\mu$ A/A + 2.0 $\mu$ A                                                             | Fluke 8508A with<br>Guildline 7520 &<br>Fluke A40B Series |
|                                                    | 2 mA                              | 6.5 $\mu$ A/A + 2.0 $\mu$ A                                                             |                                                           |
|                                                    | 20 mA                             | 8.0 $\mu$ A/A + 2.0 $\mu$ A                                                             |                                                           |
|                                                    | 200 mA                            | 33.0 $\mu$ A/A + 4.0 $\mu$ A                                                            |                                                           |
|                                                    | 2 A                               | 170.0 $\mu$ A/A + 8.0 $\mu$ A                                                           |                                                           |
|                                                    | 10 A                              | 380.0 $\mu$ A/A + 20.0 $\mu$ A                                                          |                                                           |

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## SCOPE OF CALIBRATION: ELECTRICAL

| Instrument Calibrated/<br>Measurement<br>Parameter | Range                                 | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks                                                   |
|----------------------------------------------------|---------------------------------------|-----------------------------------------------------------------------------------------|-----------------------------------------------------------|
| 2. Generating Instrument<br>Continue<br>DC CURRENT | $\pm$ (1 nA to 100 nA)                | 30 $\mu$ A/A + 0.04 nA                                                                  | HP 3458A Opt. 002                                         |
|                                                    | $\pm$ (100 nA to 1 $\mu$ A)           | 20 $\mu$ A/A + 0.04 nA                                                                  |                                                           |
|                                                    | $\pm$ (1 $\mu$ A to 10 $\mu$ A)       | 20 $\mu$ A/A + 0.1 nA                                                                   |                                                           |
|                                                    | $\pm$ (10 $\mu$ A to 100 $\mu$ A)     | 20 $\mu$ A/A + 0.8 nA                                                                   |                                                           |
|                                                    | $\pm$ (100 $\mu$ A to 1 mA)           | 20 $\mu$ A/A + 5 nA                                                                     |                                                           |
|                                                    | $\pm$ (1 mA to 10 mA)                 | 20 $\mu$ A/A + 0.05 $\mu$ A                                                             |                                                           |
|                                                    | $\pm$ (10 mA to 100 mA)               | 35 $\mu$ A/A + 0.5 $\mu$ A                                                              |                                                           |
|                                                    | $\pm$ (100 mA to 1 A)                 | 0.11 mA/A + 0.01 mA                                                                     |                                                           |
|                                                    | $\pm$ (1 pA to 20 pA)                 | 26 mA/A                                                                                 | Agilent 4339B                                             |
|                                                    | $\pm$ (20 pA to 200 pA)               | 26 mA/A                                                                                 |                                                           |
| AC CURRENT                                         | $\pm$ (200 pA to 2 nA)                | 10 mA/A                                                                                 | HP 3458A &<br>Guildline 9211A                             |
|                                                    | $\pm$ (1 A to 10 A)                   | 5.1 mA                                                                                  |                                                           |
|                                                    | $\pm$ (10 A to 100 A)                 | 0.05 A                                                                                  | Fluke 8508A with<br>Guildline 7520 &<br>Fluke A40B Series |
|                                                    |                                       |                                                                                         |                                                           |
| AC CURRENT                                         | 5 $\mu$ A to 1 A<br>(See Matrix F)    | (See Matrix F)                                                                          | HP 3458A                                                  |
|                                                    | 200 $\mu$ A to 10 A<br>(See Matrix G) | (See Matrix G)                                                                          |                                                           |

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## SCOPE OF CALIBRATION: ELECTRICAL

| Instrument Calibrated/<br>Measurement<br>Parameter | Range                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) *                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Remarks                                                   |
|----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| 2. Generating Instrument<br>Continue<br>AC CURRENT | 1 A to 50 A<br>50 Hz/ 60 Hz                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0.5 mA/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | HP 3458A & Zenith<br>H007098                              |
| RESISTANCE                                         | 0 $\Omega$ to 10 $\Omega$<br>10 $\Omega$ to 100 $\Omega$<br>0.1 k $\Omega$ to 1 k $\Omega$<br>1 k $\Omega$ to 10 k $\Omega$<br>10 k $\Omega$ to 100 k $\Omega$<br>0.1 M $\Omega$ to 1 M $\Omega$<br>1 M $\Omega$ to 10 M $\Omega$<br>10 M $\Omega$ to 100 M $\Omega$<br>100 M $\Omega$ to 1 G $\Omega$<br>1 G $\Omega$ to 2 G $\Omega$<br>2 G $\Omega$ to 20 G $\Omega$<br>20 G $\Omega$ to 200 G $\Omega$<br>0.2 T $\Omega$ to 2 T $\Omega$<br>2 T $\Omega$ to 20 T $\Omega$<br>20 T $\Omega$ to 200 T $\Omega$ | 15 $\mu\Omega/\Omega$ + 0.05 m $\Omega$<br>12 $\mu\Omega/\Omega$ + 0.5 m $\Omega$<br>10 $\mu\Omega/\Omega$ + 0.5 m $\Omega$<br>10 $\mu\Omega/\Omega$ + 5 m $\Omega$<br>10 $\mu\Omega/\Omega$ + 0.05 $\Omega$<br>15 $\mu\Omega/\Omega$ + 2 $\Omega$<br>50 $\mu\Omega/\Omega$ + 0.1 k $\Omega$<br>0.5 m $\Omega/\Omega$ + 1 k $\Omega$<br>5 m $\Omega/\Omega$ + 0.01 M $\Omega$<br>2.3 m $\Omega/\Omega$ + 0.01 M $\Omega$<br>2.3 m $\Omega/\Omega$ + 0.1 M $\Omega$<br>3.5 m $\Omega/\Omega$ + 1 M $\Omega$<br>3.5 m $\Omega/\Omega$ + 0.01 G $\Omega$<br>10 m $\Omega/\Omega$ + 0.1 G $\Omega$<br>12 m $\Omega/\Omega$ + 1 G $\Omega$ | HP 3458A Opt 002<br>& Keithley 6517 /<br>Agilent 4339A    |
|                                                    | 0 $\Omega$ to 2 $\Omega$ ,<br>20 M $\Omega$<br>100 M $\Omega$                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 8 $\mu\Omega/\Omega$<br>10 $\mu\Omega/\Omega$<br>31 $\mu\Omega/\Omega$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Fluke 8508A with<br>Guildline 7520 &<br>Fluke A40B Series |



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## SCOPE OF CALIBRATION: ELECTRICAL

| Instrument Calibrated/<br>Measurement<br>Parameter | Range                                                                                       | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks                                             |
|----------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|-----------------------------------------------------|
| 2. Generating Instrument<br>Continue               |                                                                                             |                                                                                         |                                                     |
| CAPACITANCE                                        | 1 pF to 1 mF @<br>(10 Hz to 1 MHz)                                                          | 0.5 mF/F                                                                                | HP 4284A                                            |
| INDUCTANCE                                         | 1 $\mu$ H to 10 H @<br>(10 Hz to 1 MHz)                                                     | 0.5 mH/H                                                                                |                                                     |
| High Voltage Tester<br>DC VOLTAGE                  | 0 kV to 9.99 kV<br>10 kV to <20 kV<br>20 kV to 35 kV<br>>35 kV to 40 kV                     | 0.3 mV/V + 0.03 V<br>0.35 mV/V + 0.07 V<br>0.35 mV/V + 0.07 V<br>0.4 mV/V + 0.2 V       | Vitretek 4700 with<br>(HVL-100, HVL-70<br>& HVP-35) |
| AC VOLTAGE                                         | (0 kV to 9.99 kV) @ 50/60 Hz<br>(10 kV to <20 kV) @ 50/60 Hz<br>(20 kV to 28 kV) @ 50/60 Hz | 1.2 mV/V + 0.1 V<br>1 mV/V + 0.2 V<br>1 mV/V + 0.2 V                                    |                                                     |

## Signatories:

1. Mohamed Fikri Bin Mohd Nor
2. Syahrel Bin Shari

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## SCOPE OF CALIBRATION: ELECTRICAL

Matrix D

AC Voltage Generation (Fluke 5790A)

| Range  |                 | Frequency Band |                          |                          |                        |
|--------|-----------------|----------------|--------------------------|--------------------------|------------------------|
|        |                 | 10 to 20 Hz    | 20 to 40 Hz              | 40 Hz to 20 kHz          | 20 to 50 kHz           |
| 2.2 mV | 0.6 to 2.2 mV   | 1.7 + 1.3      | 0.74 + 1.3               | 0.42 + 1.3               | 0.81 + 2               |
| 7 mV   | 1.9 to 7 mV     | 0.85 + 1.3     | 0.37 + 1.3               | 0.21 + 1.3               | 0.4 + 2                |
| 22 mV  | 8.5 to 11.5 mV  | 0.29 + 1.3     | 0.19 + 1.3               | 0.11 + 1.3               | 0.21 + 2               |
| 70 mV  | 19 to 70 mV     | 0.24 + 1.5     | 0.12 + 1.5               | 24 $\mu\text{V/V}$ + 1.5 | 0.13 + 2               |
| 220 mV | 60 to 220 mV    | 0.21 + 1.5     | 85 $\mu\text{V/V}$ + 1.5 | 38 $\mu\text{V/V}$ + 1.5 | 69 $\mu\text{V/V}$ + 2 |
| 700 mV | 190 to 700 mV   |                | 24 $\mu\text{V/V}$ + 1.5 | 33 $\mu\text{V/V}$ + 1.5 | 51 $\mu\text{V/V}$ + 2 |
| 2.2 V  | 0.6 to 2.2 V    | 0.2            | 66 $\mu\text{V/V}$       | 24 $\mu\text{V/V}$       | 46 $\mu\text{V/V}$     |
| 7 V    | 1.9 to 7 V      |                | 67 $\mu\text{V/V}$       |                          | 48 $\mu\text{V/V}$     |
| 22 V   | 6 to 22 V       |                | 68 $\mu\text{V/V}$       | 27 $\mu\text{V/V}$       | 57 $\mu\text{V/V}$     |
| 70 V   | 19 to 70 V      |                |                          | 32 $\mu\text{V/V}$       |                        |
| 220 V  | 60 to 220 V     |                | 99 $\mu\text{V/V}$       | 31 $\mu\text{V/V}$       | 69 $\mu\text{V/V}$     |
| 700 V  | 190 V to 700 V  |                |                          | 41 $\mu\text{V/V}$       | 0.13                   |
| 1000 V | 600 V to 1050 V |                |                          | 38 $\mu\text{V/V}$       |                        |

| Range  |                 | Frequency Band           |                |                |                  |
|--------|-----------------|--------------------------|----------------|----------------|------------------|
|        |                 | 50 to 100 kHz            | 100 to 300 kHz | 300 to 500 kHz | 500 kHz to 1 MHz |
| 2.2 mV | 0.6 to 2.2 mV   | 1.2 + 2.5                | 2.3 + 4        | 2.4 + 8        | 3.5 + 8          |
| 7 mV   | 1.9 to 7 mV     | 0.6 + 2.5                | 1.2 + 4        | 1.3 + 8        | 2.3 + 8          |
| 22 mV  | 8.5 to 11.5 mV  | 0.31 + 2.5               | 0.81 + 4       | 0.89 + 8       | 1.7 + 8          |
| 70 mV  | 19 to 70 mV     | 0.26 + 2.5               | 0.51 + 4       | 0.67 + 8       | 1.1 + 8          |
| 220 mV | 60 to 220 mV    | 0.16 + 2.5               | 0.25 + 4       | 0.38 + 8       | 1 + 8            |
| 700 mV | 190 to 700 mV   | 79 $\mu\text{V/V}$ + 2.5 | 0.18 + 4       | 0.3 + 8        | 0.96 + 8         |
| 2.2 V  | 0.6 to 2.2 V    | 71 $\mu\text{V/V}$       | 0.16           | 0.26           | 0.9              |
| 7 V    | 1.9 to 7 V      | 81 $\mu\text{V/V}$       | 0.19           | 0.4            | 1.2              |
| 22 V   | 6 to 22 V       |                          |                |                |                  |
| 70 V   | 19 to 70 V      | 94 $\mu\text{V/V}$       | 0.2            | 0.41           |                  |
| 220 V  | 60 to 220 V     | 98 $\mu\text{V/V}$       | 0.21           | 0.5            |                  |
| 700 V  | 190 V to 700 V  | 0.5                      | -              |                |                  |
| 1000 V | 600 V to 1050 V |                          |                |                |                  |

The expanded uncertainties given in this table are expressed in mV/V +  $\mu\text{V}$  unless otherwise stated.

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**SCOPE OF CALIBRATION: ELECTRICAL**

Matrix E

AC Voltage Generation (HP 3458A)

| Range |            | Frequency Band |              |            |             |             |
|-------|------------|----------------|--------------|------------|-------------|-------------|
|       |            | 1 to 40 Hz     | 0.1 to 1 MHz | 1 to 4 MHz | 4 to 8 MHz  | 8 to 10 MHz |
| 10 mV | 1 to 12 mV | 0.3 + 3        | 12 + 5       | 70 + 7     | 0.2 V/V + 8 | –           |

| Range  |              | Frequency Band        |             |             |             |                   |
|--------|--------------|-----------------------|-------------|-------------|-------------|-------------------|
|        |              | 1 to 40 Hz            | 1 to 2 MHz  | 2 to 4 MHz  | 4 to 8 MHz  | 8 to 10 MHz       |
| 100 mV | 10 to 120 mV | 70 $\mu$ V/V + 4      | 15 + 10     | 40 + 70     | 40 + 80     | 0.15 V/V + 0.1 mV |
| 1 V    | 0.1 V 1.2 V  | 70 $\mu$ V/V + 40     | 15 + 0.1 mV | 40 + 0.7 mV | 40 + 0.8 mV | 0.15 V/V + 1 mV   |
| 10 V   | 1 to 12 V    | 70 $\mu$ V/V + 0.4 mV | 15 + 1 mV   | 40 + 7 mV   | 40 + 8 mV   | 0.15 V/V + 10 mV  |

| Range  |              | Frequency Band |              |
|--------|--------------|----------------|--------------|
|        |              | 1 to 40 Hz     | 0.3 to 1 MHz |
| 100 V  | 10 to 120 V  | 0.2 + 4 mV     | 15 + 10 mV   |
| 1000 V | 100 to 700 V | 0.4 + 40 mV    |              |

The expanded uncertainties given in this table are expressed in mV/V +  $\mu$ V unless otherwise stated.

Matrix F

AC Current Generation (HP 3458A)

| Range       |                  | Frequency Band |              |              |                 |
|-------------|------------------|----------------|--------------|--------------|-----------------|
|             |                  | 10 to 20 Hz    | 20 to 45 Hz  | 45 to 100 Hz | 100 Hz to 5 kHz |
| 100 $\mu$ A | 5 to 120 $\mu$ A | 4 + 30 nA      | 1.5 + 30 nA  | 0.6 + 3 nA   |                 |
| 1 mA        | 0.05 to 1.2 mA   | 4 + 0.2        | 1.5 + 0.2    | 0.6 + 0.2    | 0.3 + 0.2       |
| 10 mA       | 0.5 to 12 mA     | 4 + 2          | 1.5 + 2      | 0.6 + 2      | 0.3 + 2         |
| 100 mA      | 5 to 120 mA      | 4 + 20         | 1.5 + 20     | 0.6 + 20     | 0.3 + 20        |
| 1 A         | 0.05 to 1.05 A   | 4 + 0.2 mA     | 1.6 + 0.2 mA | 0.8 + 0.2 mA | 1 + 0.2 mA      |

| Range  |                | Frequency Band |              |               |
|--------|----------------|----------------|--------------|---------------|
|        |                | 5 to 20 kHz    | 20 to 50 kHz | 50 to 100 kHz |
| 1 mA   | 0.05 to 1.2 mA | 0.6 + 0.2      | 4 + 0.4      | 5.5 + 1.5     |
| 10 mA  | 0.5 to 12 mA   | 0.6 + 2        | 4 + 4        | 5.5 + 15      |
| 100 mA | 5 to 120 mA    | 0.6 + 20       | 4 + 40       | 5.5 + 0.15 mA |
| 1 A    | 0.05 to 1.05 A | 3 + 0.2 mA     | 10 + 0.4 mA  |               |

The expanded uncertainties given in this table are expressed in mA/A +  $\mu$ A unless otherwise stated.

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**SCOPE OF CALIBRATION: ELECTRICAL**

Matrix G

AC Current Generation (Fluke 8508A with Guildline 7520 &amp; Fluke A40B Series)

| Range       | Frequency Band |              |                |                |
|-------------|----------------|--------------|----------------|----------------|
|             | 1 to 10 Hz     | 10 to 10 kHz | 10 k to 30 kHz | 30k to 100 kHz |
| 200 $\mu$ A | 260            |              | 610            | 41 mA/A        |
| 2 mA        |                |              | 610            | 41 mA/A        |
| 20 mA       | 260            |              | 610            | -              |
| 200 mA      |                |              |                |                |

| Range | Frequency Band |                |                |
|-------|----------------|----------------|----------------|
|       | 10 to 2 kHz    | 10 k to 10 kHz | 10 k to 30 kHz |
| 2 A   | 610            | 710            | 31 mA/A        |
| 20 A  | 810            | 26 mA/A        | -              |

The expanded uncertainties given in this table are expressed in mA/A unless otherwise stated.

**Signatories:**

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**SCOPE OF CALIBRATION: ELECTRICAL****SITE CALIBRATION: CATEGORY I**

| Instrument Calibrated/<br>Measurement Parameter | Range                                                                           | Calibration and<br>Measurement<br>Capability Expressed<br>as an Uncertainty ( $\pm$ ) *                           | Remarks      |
|-------------------------------------------------|---------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|--------------|
| 1. Measuring Instrument<br>DC VOLTAGE           | $\pm 220$ mV Range<br>$\pm$ (0 mV to 220 mV)                                    | $9 \mu\text{V/V} + 0.8 \mu\text{V}$                                                                               | Fluke 5700A  |
|                                                 | $\pm 2.2$ V Range<br>$\pm$ (0 V to 2.2 V)                                       | $8 \mu\text{V/V} + 1.2 \mu\text{V}$                                                                               |              |
|                                                 | $\pm 11$ V Range<br>$\pm$ (0 V to 11 V)                                         | $8 \mu\text{V/V} + 4 \mu\text{V}$                                                                                 |              |
|                                                 | $\pm 22$ V Range<br>$\pm$ (0 V to 22 V)                                         | $8 \mu\text{V/V} + 8 \mu\text{V}$                                                                                 |              |
|                                                 | $\pm 220$ V Range<br>$\pm$ (0 V to 220 V)                                       | $9 \mu\text{V/V} + 0.1 \text{ mV}$                                                                                |              |
|                                                 | $\pm 1100$ V Range<br>$\pm$ (100 V to 1100 V)                                   | $11 \mu\text{V/V} + 0.6 \text{ mV}$                                                                               |              |
| AC VOLTAGE                                      | 2.2 mV to 220 V<br>(See Matrix A)                                               | (See Matrix A)                                                                                                    | Fluke 5700A  |
|                                                 | 1100 V Range (110 V to 1100 V)<br>50 Hz to 1 kHz                                | $90 \mu\text{V/V} + 4 \text{ mV}$                                                                                 |              |
|                                                 | <u>800 V to 1050 V</u><br>1 kHz to 3 kHz<br>3 kHz to 10 kHz<br>10 kHz to 20 kHz | $0.8 \text{ mV/V} + 0.13 \text{ V}$<br>$0.8 \text{ mV/V} + 0.21 \text{ V}$<br>$1.2 \text{ mV/V} + 0.32 \text{ V}$ | Wavetek 9100 |

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**SCOPE OF CALIBRATION: ELECTRICAL****SITE CALIBRATION: CATEGORY I**

| Instrument Calibrated/<br>Measurement Parameter   | Range                                                                                                                                                                                                                                                                                                                                                                                  | Calibration and<br>Measurement<br>Capability Expressed<br>as an Uncertainty ( $\pm$ ) *                                                                                                                       | Remarks      |
|---------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| 1. Measuring Instrument<br>Continue<br>DC CURRENT | $\pm 220 \mu\text{A}$ Range<br>$\pm (0 \text{ mA to } 220 \mu\text{A})$<br><br>$\pm 2.2 \text{ mA}$ Range<br>$\pm (0 \text{ mA to } 2.2 \text{ mA})$<br><br>$\pm 22 \text{ mA}$ Range<br>$\pm (0 \text{ mA to } 22 \text{ mA})$<br><br>$\pm 220 \text{ mA}$ Range<br>$\pm (0 \text{ mA to } 220 \text{ mA})$<br><br>$\pm 2.2 \text{ A}$ Range<br>$\pm (0 \text{ A to } 2.2 \text{ A})$ | $60 \mu\text{A/A} + 10 \text{ nA}$<br><br>$60 \mu\text{A/A} + 10 \text{ nA}$<br><br>$60 \mu\text{A/A} + 0.1 \mu\text{A}$<br><br>$70 \mu\text{A/A} + 1 \mu\text{A}$<br><br>$95 \mu\text{A/A} + 30 \mu\text{A}$ | Fluke 5700A  |
|                                                   | $\pm 3.2 \text{ A}$ Range<br>$\pm (0.32 \text{ A to } 3.2 \text{ A})$<br><br>$\pm 10.5 \text{ A}$ Range<br>$\pm (3.2 \text{ A to } 10.5 \text{ A})$<br><br>$\pm 20 \text{ A}$ Range<br>$\pm (10.5 \text{ A to } 20 \text{ A})$                                                                                                                                                         | $0.6 \text{ mA/A} + 0.12 \text{ mA}$<br><br>$0.55 \text{ mA/A} + 0.94 \text{ mA}$<br><br>$0.55 \text{ mA/A} + 4.5 \text{ mA}$                                                                                 | Wavetek 9100 |
| AC CURRENT                                        | $9 \mu\text{A}$ to $2.2 \text{ A}$<br>(See Matrix B)                                                                                                                                                                                                                                                                                                                                   | (See Matrix B)                                                                                                                                                                                                | Fluke 5700A  |



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**SCOPE OF CALIBRATION: ELECTRICAL****SITE CALIBRATION: CATEGORY I**

| Instrument Calibrated/<br>Measurement Parameter    | Range                                                                                                                                                                                            | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) *                               | Remarks                                                       |
|----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|
| 1. Measuring Instrument<br>Continue<br>AC CURRENT  | <u>0.32 A to 3.2 A</u><br>10 Hz to 3 kHz<br>3 kHz to 10 kHz<br><br><u>3.2 A to 10.5 A</u><br>10 Hz to 3 kHz<br>3 kHz to 10 kHz<br><br><u>10.5 A to 20 A</u><br>10 Hz to 3 kHz<br>3 kHz to 10 kHz | 1 mA/A + 0.48 mA<br>2.5 mA/A + 2.6 mA<br><br>2 mA/A + 3 mA<br>5 mA/A + 10 mA<br><br>2 mA/A + 6.9 mA<br>5 mA/A + 23 mA | Wavetek 9100                                                  |
| Residual Current                                   | <u>3 mA to 3A</u><br>At Time interval up to 5 s<br>At Time interval <190 ms                                                                                                                      | 0.14 mA/A<br>0.3 mA/A                                                                                                 | For RCD Tester<br>Calibrator<br>(using<br>Transmille<br>3200) |
| CAPACITANCE                                        | (See Matrix C)                                                                                                                                                                                   | (See Matrix C)                                                                                                        | Wavetek 9100                                                  |
| Fixed Value                                        | <u>20Hz to 1 MHz</u><br>1 pF, 10 pF, 100 pF, 1000 pF,<br>0.02 $\mu$ F, 0.1 $\mu$ F and 1.0 $\mu$ F                                                                                               | 1 mF/F                                                                                                                | HP 1600A<br>series                                            |
| INDUCTANCE<br>Fixed Value                          | <u>100 <math>\mu</math>H @ 1 kHz</u><br><u>(1, 10, 100) mH @ 1 kHz</u><br><u>1H @ 1 kHz</u>                                                                                                      | 2.5 mH/H<br>1 mH/H<br>1 mH/H                                                                                          | Ando RS-100<br>series                                         |
| POWER/ ENERGY<br>(DC)                              | 1 kW to 20 kW<br>0.1 W to 1 kW                                                                                                                                                                   | 0.7 mW/W<br>0.22 mW/W                                                                                                 | Fluke 5522A                                                   |
| POWER/ ENERGY<br>(AC), (45 Hz to 65 Hz<br>at PF=1) | 10 kW to 20 kW<br>1 W to 10 kW<br>0.1 W to 1 W                                                                                                                                                   | 1 mW/W<br>0.9 mW/W<br>1 mW/W                                                                                          |                                                               |

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**SCOPE OF CALIBRATION: ELECTRICAL****SITE CALIBRATION: CATEGORY I**

| Instrument Calibrated/<br>Measurement Parameter                  | Range                                                                                                                                                                                                                                                                                                                   | Calibration and<br>Measurement<br>Capability Expressed<br>as an Uncertainty ( $\pm$ ) *                                                                                                                                                                                                                                                                                                                                                                                             | Remarks                                                    |
|------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|
| 1. Measuring Instrument<br>Continue<br>RESISTANCE<br>Fixed Value | 1 m $\Omega$<br>10 m $\Omega$<br>100 m $\Omega$<br>1 $\Omega$<br>1.9 $\Omega$<br>10 $\Omega$<br>19 $\Omega$<br>100 $\Omega$<br>190 $\Omega$<br>1 k $\Omega$<br>1.9 k $\Omega$<br>10 k $\Omega$<br>19 k $\Omega$<br>100 k $\Omega$<br>190 k $\Omega$<br>1 M $\Omega$<br>1.9 M $\Omega$<br>10 M $\Omega$<br>19 M $\Omega$ | 0.2 m $\Omega/\Omega$<br>0.1 m $\Omega/\Omega$<br>0.02 m $\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>0.11 m $\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>31 $\mu\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>0.02 m $\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>15 $\mu\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>14 $\mu\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>15 $\mu\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>24 $\mu\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>0.05 m $\Omega/\Omega$ | Fluke 5700A &<br>Fluke 742A<br>Series                      |
|                                                                  | 100 M $\Omega$<br>1 G $\Omega$<br>10 G $\Omega$<br>100 G $\Omega$<br>1 T $\Omega$                                                                                                                                                                                                                                       | 0.13 m $\Omega/\Omega$<br>5 $\mu\Omega/\Omega$<br>0.02 $\Omega/\Omega$<br>0.05 $\Omega/\Omega$<br>0.05 $\Omega/\Omega$                                                                                                                                                                                                                                                                                                                                                              | Fluke 5700A<br>& Takeda Riken<br>TR45 Standard<br>Resistor |

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**SCOPE OF CALIBRATION: ELECTRICAL****SITE CALIBRATION: CATEGORY I**

| Instrument Calibrated/<br>Measurement Parameter                       | Range                                                                | Calibration and<br>Measurement<br>Capability Expressed<br>as an Uncertainty ( $\pm$ ) * | Remarks                                     |
|-----------------------------------------------------------------------|----------------------------------------------------------------------|-----------------------------------------------------------------------------------------|---------------------------------------------|
| HIGH VOLTAGE<br>METER<br>DC Voltage<br><br>AC Voltage @<br>(50/60) Hz | 0.5 kV to 10 kV                                                      | 0.35 mV/V + 0.07 V                                                                      | Vitretek<br>(4700 & HVP 35)<br>and TOS 5101 |
|                                                                       |                                                                      | 1 mV/V + 0.2 V                                                                          |                                             |
| CLAMP METER<br>DC Current<br>10 – Turn Coil<br><br>50 – Turn Coil     | $\pm 3.2$ A to 32 A<br>$\pm 32$ A to 105 A<br>$\pm 105$ A to 200 A   | 0.06 mA/A + 1.18 mA<br>0.55 mA/A + 9.4 mA<br>0.55 mA/A + 45 mA                          |                                             |
|                                                                       | $\pm 16$ A to 160 A<br>$\pm 160$ A to 525 A<br>$\pm 525$ A to 1000 A | 0.6 mA/A + 5.9 mA<br>0.55 mA/A + 47 mA<br>0.55 mA/A + 0.23 A                            |                                             |
| AC Current<br><u>10 – Turn Coil</u>                                   | <u>3.2 A to 32 A</u><br>10 Hz to 100 Hz<br>100 Hz to 440 Hz          | 2 mA/A + 5.5 mA<br>7.8 mA/A + 27 mA                                                     | Wavetek 9100<br>c/w<br>Current Coil         |
|                                                                       | <u>32 A to 200 A</u><br>10 Hz to 100 Hz<br>100 Hz to 440 Hz          | 2.1 mA/A + 90 mA<br>6.7 mA/A + 0.25 A                                                   |                                             |
| CLAMP METER<br><u>50 – Turn Coil</u>                                  | <u>16 A to 160 A</u><br>10 Hz to 100 Hz                              | 2 mA/A + 28 mA                                                                          |                                             |
|                                                                       | <u>160 A to 1000 A</u><br>10 Hz to 100 Hz                            | 2.1 mA/A + 0.45 A                                                                       |                                             |

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**SCOPE OF CALIBRATION: ELECTRICAL****SITE CALIBRATION: CATEGORY I**

| Instrument Calibrated/<br>Measurement Parameter             | Range                                                                                                                                                                                                                                                                                                                                                              | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) *                                                                                                                                                                                                                                                         | Remarks                                           |
|-------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|
| 1. Measuring Instrument<br>Continue                         |                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                 |                                                   |
| INSULATION TESTER                                           | (1 k $\Omega$ to 10 k $\Omega$ ) @ 10 V                                                                                                                                                                                                                                                                                                                            | 26 $\mu\Omega/\Omega$ + 0.6 $\Omega$                                                                                                                                                                                                                                                                                                            | Biddle726349                                      |
|                                                             | (10 k $\Omega$ to 100 k $\Omega$ ) @ 50 V<br>(0.1 M $\Omega$ to 1 M $\Omega$ ) @ 150 V<br>(1 M $\Omega$ to 10 M $\Omega$ ) @ 300 V<br>(10 M $\Omega$ to 100 M $\Omega$ ) @ 500 V<br>(0.1 G $\Omega$ to 1 G $\Omega$ ) @ 1 kV<br>(1 G $\Omega$ to 10 G $\Omega$ ) @ 5 kV<br>(10 G $\Omega$ to 100 G $\Omega$ ) @ 5 kV<br>(100 G $\Omega$ to 600 G $\Omega$ ) @ 5 kV | 16 $\mu\Omega/\Omega$ + 0.47 $\Omega$<br>34 $\mu\Omega/\Omega$ + 0.68 k $\Omega$<br>5.1 $\mu\Omega/\Omega$ + 0.67 k $\Omega$<br>73 $\mu\Omega/\Omega$ + 5.5 k $\Omega$<br>73 $\mu\Omega/\Omega$ + 55 k $\Omega$<br>0.28 m $\Omega/\Omega$ + 0.7 M $\Omega$<br>4.1 m $\Omega/\Omega$ + 0.43 M $\Omega$<br>4.3 m $\Omega/\Omega$ + 4.1 M $\Omega$ | IET HRRS-Q-9-10k                                  |
| OSCILLOSCOPE<br>Vertical Deflection<br>DC Signal            | 0 V to $\pm$ 6.6 V (50 $\Omega$ Load)<br>0 V to $\pm$ 130 V (1 M $\Omega$ Load)                                                                                                                                                                                                                                                                                    | 2.5 mV/V + 0.04 mV<br>0.5 mV/V + 0.04 mV                                                                                                                                                                                                                                                                                                        | Fluke 5500A SC600                                 |
| Vertical Deflection<br>Square Wave Signal                   | $\pm$ 1 mVp-p to $\pm$ 6.6 Vp-p<br>(50 $\Omega$ Load)<br>$\pm$ 1 mVp-p to $\pm$ 130 Vp-p<br>(1 M $\Omega$ Load)                                                                                                                                                                                                                                                    | 2.5 mVp-p/Vp-p +<br>0.04mVp-p<br>1 mVp-p/Vp-p +<br>0.04 mVp-p                                                                                                                                                                                                                                                                                   |                                                   |
| Horizontal Deflection<br>Time Markers<br>(50 $\Omega$ Load) | 2 ns/div to 20 ms/div<br>50 ms/div to 5 s/div                                                                                                                                                                                                                                                                                                                      | 2.5 $\mu$ s/s<br>(25+(Output x 1000)) $\mu$ s/s                                                                                                                                                                                                                                                                                                 |                                                   |
| Risetime                                                    | $\leq$ 300 ps                                                                                                                                                                                                                                                                                                                                                      | +0 ns / -0.1 ns                                                                                                                                                                                                                                                                                                                                 |                                                   |
| Bandwidth Frequency                                         | 50 kHz to 600 MHz                                                                                                                                                                                                                                                                                                                                                  | 2.5 $\mu$ Hz/Hz                                                                                                                                                                                                                                                                                                                                 |                                                   |
|                                                             | 600 MHz to 40 GHz<br>(+11 dBm to -135 dBm)                                                                                                                                                                                                                                                                                                                         | 7 nHz/Hz                                                                                                                                                                                                                                                                                                                                        | Agilent E8257D<br>Reference to<br>SPIRENT STR4500 |
| Bandwidth Amplitude                                         | 50 kHz to 600 MHz                                                                                                                                                                                                                                                                                                                                                  | 0.03 Vp-p                                                                                                                                                                                                                                                                                                                                       | Fluke 5500A SC600                                 |
|                                                             | 600 MHz to 40 GHz<br>(+11 dBm to -135 dBm)                                                                                                                                                                                                                                                                                                                         | 0.92 dBm                                                                                                                                                                                                                                                                                                                                        | Agilent E8257D                                    |

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**SCOPE OF CALIBRATION: ELECTRICAL****SITE CALIBRATION: CATEGORY I**Matrix A  
AC Voltage Measurement

| Range  |                   | Frequency   |              |               |              |
|--------|-------------------|-------------|--------------|---------------|--------------|
|        |                   | Hz          |              | kHz           |              |
|        |                   | 10 to 20    | 20 to 40     | 0.04 to 20    | 20 to 50     |
| 2.2 mV | 0.22 mV to 2.2 mV | 0.6 + 0.005 | 0.24 + 0.005 | 0.12 + 0.005  | 0.41 + 0.005 |
| 22 mV  | 2.2 mV to 22 mV   | 0.6 + 0.006 | 0.24 + 0.006 | 0.12 + 0.006  | 0.41 + 0.006 |
| 220 mV | 22 mV to 220 mV   | 0.6 + 0.016 | 0.24 + 0.01  | 0.11 + 0.01   | 0.36 + 0.01  |
| 2.2 V  | 0.22 V to 2.2 V   | 0.6 + 0.1   | 0.18 + 0.03  | 0.085 + 0.007 | 0.14 + 0.02  |
| 22 V   | 2.2 V to 22 V     | 0.6 + 1     | 0.18 + 0.3   | 0.085 + 0.07  | 0.14 + 0.2   |
| 220 V  | 22 V to 220 V     | 0.6 + 10    | 0.18 + 3     | 0.09 + 1      | 0.25 + 4     |

| Range  |                   | Frequency    |             |            |            |
|--------|-------------------|--------------|-------------|------------|------------|
|        |                   | MHz          |             |            |            |
|        |                   | 0.05 to 0.1  | 0.1 to 0.3  | 0.3 to 0.5 | 0.5 to 1   |
| 2.2 mV | 0.22 mV to 2.2 mV | 0.95 + 0.008 | 1.3 + 0.015 | 1.8 + 0.03 | 3.6 + 0.03 |
| 22 mV  | 2.2 mV to 22 mV   | 0.95 + 0.008 | 1.3 + 0.015 | 1.8 + 0.03 | 3.6 + 0.03 |
| 220 mV | 22 mV to 220 mV   | 0.9 + 0.03   | 1.1 + 0.03  | 1.8 + 0.04 | 3.6 + 0.1  |
| 2.2 V  | 0.22 V to 2.2 V   | 0.28 + 0.08  | 0.48 + 0.15 | 1.2 + 0.4  | 2.4 + 1    |
| 22 V   | 2.2 V to 22 V     | 0.28 + 0.4   | 0.6 + 1.7   | 1.4 + 5    | 3 + 9      |
| 220 V  | 22 V to 220 V     | 0.6 + 10     | 1.6 + 110   | 5.4 + 110  | 13 + 220   |

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

Matrix B  
AC Current Measurement

| Range                    | Frequency (kHz) |              |             |            |            |
|--------------------------|-----------------|--------------|-------------|------------|------------|
|                          | 0.01 to 0.02    | 0.02 to 0.04 | 0.04 to 1   | 1 to 5     | 5 to 10    |
| 9 $\mu$ A to 220 $\mu$ A | 0.8 + 0.03      | 0.42 + 0.025 | 0.16 + 0.02 | 0.7 + 0.05 | 1.8 + 0.1  |
| 0.22 mA to 2.2 mA        | 0.8 + 0.05      | 0.42 + 0.04  | 0.16 + 0.04 | 0.7 + 0.5  | 1.8 + 1    |
| 2.2 mA to 22 mA          | 0.8 + 0.5       | 0.42 + 0.4   | 0.16 + 0.4  | 0.7 + 10   | 1.8 + 0.01 |
| 22 mA to 220 mA          | 0.8 + 5         | 0.42 + 4     | 0.18 + 4    | 0.7 + 50   | 1.8 + 100  |
| 0.22 A to 2.2 A          | -               | -            | 0.75 + 40   | 0.85 + 100 | 10 + 200   |

The expanded uncertainties given in this table are expressed in mA/A +  $\mu$ A

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**SCOPE OF CALIBRATION: ELECTRICAL****SITE CALIBRATION: CATEGORY I**Matrix C  
Capacitance Measurement

| Range                     | Frequency             |                        |
|---------------------------|-----------------------|------------------------|
|                           | $\leq 350$ Hz         | 350 Hz to 1.5 kHz      |
| 0.5 nF to 4 nF            | 3 mF/F + 15 pF        | 6 mF/F + 0.03 nF       |
| 4 nF to 40 nF             | 3 mF/F + 30 pF        | 6 mF/F + 0.06 nF       |
| 40 nF to 400 nF           | 3 mF/F + 0.16 nF      | 6 mF/F + 0.32 nF       |
| 400 nF to 4 $\mu$ F       | 4 mF/F + 1.6 nF       | 8 mF/F + 3.2 nF        |
| 4 $\mu$ F to 40 $\mu$ F   | 5 mF/F + 16 nF        | 10 mF/F + 32 nF        |
| 40 $\mu$ F to 400 $\mu$ F | 5 mF/F + 0.16 $\mu$ F | 10 mF/F + 0.32 $\mu$ F |
| 400 $\mu$ F to 4 mF       | 5 mF/F + 1.6 $\mu$ F  | 10 mF/F + 3.2 $\mu$ F  |
| 4 mF to 40 mF             | 10 mF/F + 0.06 mF     | 20 mF/F + 0.12 mF      |

| Instrument Calibrated/<br>Measurement<br>Parameter | Range                                                            | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks           |
|----------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------------|-------------------|
| 2. Generating Instrument<br>DC VOLTAGE             | $\pm 100$ mV Range<br>$\pm (100 \mu\text{V to } 120 \text{ mV})$ | $5 \mu\text{V/V} + 0.3 \mu\text{V}$                                                     | HP 3458A Opt. 002 |
|                                                    | $\pm 1$ V Range<br>$\pm (100 \text{ mV to } 1.2 \text{ V})$      | $4 \mu\text{V/V} + 0.3 \mu\text{V}$                                                     |                   |
|                                                    | $\pm 10$ V Range<br>$\pm (1 \text{ V to } 12 \text{ V})$         | $4 \mu\text{V/V} + 0.5 \mu\text{V}$                                                     |                   |
|                                                    | $\pm 100$ V Range<br>$\pm (10 \text{ V to } 120 \text{ V})$      | $6 \mu\text{V/V} + 0.03 \text{ mV}$                                                     |                   |
|                                                    | $\pm 1000$ V Range<br>$\pm (100 \text{ V to } 1050 \text{ V})$   | $6 \mu\text{V/V} + 0.1 \text{ mV}$                                                      |                   |
| AC VOLTAGE                                         | 10 mV to 700V<br>(See Matrix D)                                  | (See Matrix D)                                                                          | HP 3458A          |
| AC CURRENT                                         | 5 $\mu$ A to 1 A<br>(See Matrix E)                               | (See Matrix E)                                                                          |                   |

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**SCOPE OF CALIBRATION: ELECTRICAL****SITE CALIBRATION: CATEGORY I**

| Instrument Calibrated/<br>Measurement<br>Parameter | Range                                                   | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks                       |
|----------------------------------------------------|---------------------------------------------------------|-----------------------------------------------------------------------------------------|-------------------------------|
| 2. Generating Instrument<br>Continue<br>AC CURRENT | 1 A to 50 A<br>50 Hz/ 60 Hz                             | 0.5 mA/A                                                                                | HP 3458A & Zenith<br>H007098  |
|                                                    | <u>50 A to 1000 A</u><br>50 Hz/ 60 Hz<br>40 Hz to 1 kHz | 15 mA/A + 2 A<br>0.03 A/A + 4 A                                                         | Kyoritsu 2003                 |
| DC CURRENT                                         | $\pm$ (1 nA to 100 nA)                                  | 30 $\mu$ A/A + 0.04 nA                                                                  | HP 3458A                      |
|                                                    | $\pm$ (100 nA to 1 $\mu$ A)                             | 20 $\mu$ A/A + 0.04 nA                                                                  |                               |
|                                                    | $\pm$ (1 $\mu$ A to 10 $\mu$ A)                         | 20 $\mu$ A/A + 0.1 nA                                                                   |                               |
|                                                    | $\pm$ (10 $\mu$ A to 100 $\mu$ A)                       | 20 $\mu$ A/A + 0.8 nA                                                                   |                               |
|                                                    | $\pm$ (100 $\mu$ A to 1 mA)                             | 20 $\mu$ A/A + 5 nA                                                                     |                               |
|                                                    | $\pm$ (1 mA to 10 mA)                                   | 20 $\mu$ A/A + 0.05 $\mu$ A                                                             |                               |
|                                                    | $\pm$ (10 mA to 100 mA)                                 | 35 $\mu$ A/A + 0.5 $\mu$ A                                                              | HP 3458A &<br>Guideline 9211A |
|                                                    | $\pm$ (100 mA to 1 A)                                   | 0.11 mA/A + 0.01 mA                                                                     |                               |
|                                                    |                                                         |                                                                                         |                               |
|                                                    | $\pm$ (1 A to 10 A)                                     | 5.1 mA                                                                                  | Kyoritsu 2003                 |
|                                                    | $\pm$ (10 A to 100 A)                                   | 0.05 A                                                                                  |                               |
|                                                    | $\pm$ (100 A to 1000 A)                                 | 15 mA/A + 2A                                                                            |                               |
| CAPACITANCE                                        | 1 pF to 1 mF @<br>(10 Hz to 1 MHz)                      | 0.5 mF/F                                                                                | HP 4284A                      |
| INDUCTANCE                                         | 1 $\mu$ H to 10 H @<br>(10 Hz to 1 MHz)                 | 0.5 mH/H                                                                                |                               |

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SCOPE OF CALIBRATION: ELECTRICAL

SITE CALIBRATION: CATEGORY I

| Instrument Calibrated/<br>Measurement<br>Parameter | Range                                                                                                                                                                                                                                                                                                                                                                                                        | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) *                                                                                                                                                                                                                                                                                                                                               | Remarks                                             |
|----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| 2. Generating Instrument<br>Continue<br>RESISTANCE | $0\ \Omega$ to $10\ \Omega$<br>$10\ \Omega$ to $100\ \Omega$<br>$0.1\ \text{k}\Omega$ to $1\ \text{k}\Omega$<br>$1\ \text{k}\Omega$ to $10\ \text{k}\Omega$<br>$10\ \text{k}\Omega$ to $100\ \text{k}\Omega$<br>$0.1\ \text{M}\Omega$ to $1\ \text{M}\Omega$<br>$1\ \text{M}\Omega$ to $10\ \text{M}\Omega$<br>$10\ \text{M}\Omega$ to $100\ \text{M}\Omega$<br>$100\ \text{M}\Omega$ to $1\ \text{G}\Omega$ | $15\ \mu\Omega/\Omega + 0.05\ \text{m}\Omega$<br>$12\ \mu\Omega/\Omega + 0.05\ \text{m}\Omega$<br>$10\ \mu\Omega/\Omega + 0.05\ \text{m}\Omega$<br>$10\ \mu\Omega/\Omega + 5\ \text{m}\Omega$<br>$10\ \mu\Omega/\Omega + 0.05\ \Omega$<br>$15\ \mu\Omega/\Omega + 2\ \Omega$<br>$50\ \mu\Omega/\Omega + 0.1\ \text{k}\Omega$<br>$0.5\ \text{m}\Omega/\Omega + 1\ \text{k}\Omega$<br>$5\ \text{m}\Omega/\Omega + 0.01\ \text{M}\Omega$ | HP 3458A                                            |
| High Voltage Tester<br>DC VOLTAGE                  | $0\ \text{kV}$ to $9.9\ \text{kV}$<br>$10\ \text{kV}$ to $<20\ \text{kV}$<br>$20\ \text{kV}$ to $35\ \text{kV}$<br>$>35\ \text{kV}$ to $40\ \text{kV}$                                                                                                                                                                                                                                                       | $0.3\ \text{mV/V} + 0.03\ \text{V}$<br>$0.35\ \text{mV/V} + 0.07\ \text{V}$<br>$0.35\ \text{mV/V} + 0.07\ \text{V}$<br>$0.4\ \text{mV/V} + 0.2\ \text{V}$                                                                                                                                                                                                                                                                             | Vitretek 4700 with<br>(HVL-100, HVL-70 &<br>HVP-35) |
| AC VOLTAGE                                         | $(0\ \text{kV}$ to $9.99\ \text{kV}) @ 50/60\text{Hz}$<br>$(10\ \text{kV}$ to $20\ \text{kV}) @ 50/60\ \text{Hz}$<br>$(20\ \text{kV}$ to $28\ \text{kV}) @ 50/60\ \text{Hz}$                                                                                                                                                                                                                                 | $1.2\ \text{mV/V} + 0.1\ \text{V}$<br>$1\ \text{mV/V} + 0.2\ \text{V}$<br>$1\ \text{mV/V} + 0.2\ \text{V}$                                                                                                                                                                                                                                                                                                                            |                                                     |



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## SCOPE OF CALIBRATION:

## ELECTRICAL

## SITE CALIBRATION:

## CATEGORY I

Matrix D

AC Voltage Generation (HP 3458A)

| Range |            | Frequency Band |              |            |             |             |
|-------|------------|----------------|--------------|------------|-------------|-------------|
|       |            | 1 to 40 Hz     | 0.1 to 1 MHz | 1 to 4 MHz | 4 to 8 MHz  | 8 to 10 MHz |
| 10 mV | 1 to 12 mV | 0.3 + 3        | 12 + 5       | 70 + 7     | 0.2 V/V + 8 | –           |

| Range  |              | Frequency Band        |             |             |             |                   |
|--------|--------------|-----------------------|-------------|-------------|-------------|-------------------|
|        |              | 1 to 40 Hz            | 1 to 2 MHz  | 2 to 4 MHz  | 4 to 8 MHz  | 8 to 10 MHz       |
| 100 mV | 10 to 120 mV | 70 $\mu$ V/V + 4      | 15 + 10     | 40 + 70     | 40 + 80     | 0.15 V/V + 0.1 mV |
| 1 V    | 0.1 V 1.2 V  | 70 $\mu$ V/V + 40     | 15 + 0.1 mV | 40 + 0.7 mV | 40 + 0.8 mV | 0.15 V/V + 1 mV   |
| 10 V   | 1 to 12 V    | 70 $\mu$ V/V + 0.4 mV | 15 + 1 mV   | 40 + 7 mV   | 40 + 8 mV   | 0.15 V/V + 10 mV  |

| Range  |              | Frequency Band |              |
|--------|--------------|----------------|--------------|
|        |              | 1 to 40 Hz     | 0.3 to 1 MHz |
| 100 V  | 10 to 120 V  | 0.2 + 4 mV     | 15 + 10 mV   |
| 1000 V | 100 to 700 V | 0.4 + 40 mV    |              |

The expanded uncertainties given in this table are expressed in mV/V +  $\mu$ V unless otherwise stated.

Matrix E

AC Current Generation (HP 3458A)

| Range       |                  | Frequency Band |              |              |                 |
|-------------|------------------|----------------|--------------|--------------|-----------------|
|             |                  | 10 to 20 Hz    | 20 to 45 Hz  | 45 to 100 Hz | 100 Hz to 5 kHz |
| 100 $\mu$ A | 5 to 120 $\mu$ A | 4 + 30 nA      | 1.5 + 30 nA  | 0.6 + 3 nA   |                 |
| 1 mA        | 0.05 to 1.2 mA   | 4 + 0.2        | 1.5 + 0.2    | 0.6 + 0.2    | 0.3 + 0.2       |
| 10 mA       | 0.5 to 12 mA     | 4 + 2          | 1.5 + 2      | 0.6 + 2      | 0.3 + 2         |
| 100 mA      | 5 to 120 mA      | 4 + 20         | 1.5 + 20     | 0.6 + 20     | 0.3 + 20        |
| 1 A         | 0.05 to 1.05 A   | 4 + 0.2 mA     | 1.6 + 0.2 mA | 0.8 + 0.2 mA | 1 + 0.2 mA      |

| Range  |                | Frequency Band |              |               |
|--------|----------------|----------------|--------------|---------------|
|        |                | 5 to 20 kHz    | 20 to 50 kHz | 50 to 100 kHz |
| 1 mA   | 0.05 to 1.2 mA | 0.6 + 0.2      | 4 + 0.4      | 5.5 + 1.5     |
| 10 mA  | 0.5 to 12 mA   | 0.6 + 2        | 4 + 4        | 5.5 + 15      |
| 100 mA | 5 to 120 mA    | 0.6 + 20       | 4 + 40       | 5.5 + 0.15 mA |
| 1 A    | 0.05 to 1.05 A | 3 + 0.2 mA     | 10 + 0.4 mA  |               |

The expanded uncertainties given in this table are expressed in mA/A +  $\mu$ A unless otherwise stated.

## Signatories:

1. Mohamed Fikri Bin Mohd Nor
2. Syahrel Bin Shari

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## SCOPE OF CALIBRATION: ELECTRICAL (RF)

| Instrument Calibrated/<br>Measurement<br>Parameter | Range                                                                                    | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks                                                                |
|----------------------------------------------------|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| 1. Measuring Instrument<br>Frequency               | 1 $\mu$ Hz to 80 MHz<br>(10 mVpp to 10 Vpp)<br>250 kHz to 40 GHz<br>(+11 dBm to -135dBm) | 0.23 nHz/Hz + 0.67 mHz<br><br>5.2 nHz/Hz + 46 $\mu$ Hz                                  | (Agilent 33250A or<br>Agilent E8257D)<br>Reference to<br>Pendulum 6689 |
| Amplitude                                          | 10 mVp-p to 10 Vp-p<br>(1 $\mu$ Hz to 80 MHz, Into 50 $\Omega$ )                         | 10 mVpp/Vpp + 1 mVpp                                                                    | Agilent 33250A                                                         |
| Flatness                                           | +11 dBm to -135dBm<br>(250 kHz to 40 GHz)                                                | 0.92 dBm                                                                                | Agilent E8257D                                                         |
|                                                    | Sine Wave Relative to 1 kHz<br>(Auto range on)                                           | 0.4 dBm                                                                                 | Agilent 33250A                                                         |
| 2. Generating Instrument<br>FREQUENCY              | 1 Hz to 5 GHz                                                                            | 0.32 nHz/Hz                                                                             | HP53132A<br>Reference to<br>Pendulum 6689                              |
| AMPLITUDE/ LEVEL                                   | -20 dBm to +30 dBm<br>(100 kHz to 2.6 GHz)                                               | 0.04 dBm                                                                                | HP 8902 with<br>11722A                                                 |
| RF AMPLITUDE/<br>LEVEL                             | -36 dB to +20 dB<br>(9 kHz to 6 GHz)                                                     | 38 mdBm/dBm + 5.3 mdBm                                                                  | Agilent E4419B<br>with E9304A                                          |
| TUNED RF LEVEL                                     | -127 dB to 0 dB<br>(2.5 MHz to 1.3 GHz)                                                  | 0.07 dBm                                                                                | HP 8902 with<br>11722A                                                 |

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**SCOPE OF CALIBRATION: ELECTRICAL (RF)**

| Instrument Calibrated/<br>Measurement Parameter                                                                              | Range                                                                                 | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks                |
|------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|------------------------|
| 2. Generating Instrument<br>Continue<br>MODULATION<br>Related Signal:<br>Amplitude Modulation<br>(AM)<br>AM Depth: 5% to 99% | Carrier Frequency<br>150 kHz to 10 MHz<br>Modulation Frequency<br>50 Hz to 10 kHz     | 0.17 %                                                                                  | HP 8902 with<br>11722A |
|                                                                                                                              | Carrier Frequency<br>150 kHz to 1300 MHz<br>Modulation Frequency<br>20 Hz to 10 kHz   | 0.19 %                                                                                  |                        |
|                                                                                                                              | Carrier Frequency<br>10 MHz to 1300 MHz<br>Modulation Frequency<br>50 Hz to 100 kHz   | 0.13 %                                                                                  |                        |
| Frequency Modulation<br>(FM)<br>FM Deviation:<br>$\leq 40$ kHz peak                                                          | Carrier Frequency<br>150 kHz to 10 MHz<br>Modulation Frequency<br>20 Hz to 10 kHz     | 0.13 kHz                                                                                |                        |
| FM Deviation:<br>$\leq 400$ kHz peak                                                                                         | Carrier Frequency<br>10 MHz to 1300 MHz<br>Modulation Frequency<br>50 Hz to 100 kHz   | 0.03 kHz                                                                                |                        |
|                                                                                                                              | Carrier Frequency<br>10 MHz to 1300 MHz<br>Modulation Frequency<br>100 kHz to 200 kHz | 0.32 kHz                                                                                |                        |
| Phase Modulation<br>( $\Phi$ M)<br>$\Phi$ M Deviation:<br>$\leq 40$ Radians peak                                             | Carrier Frequency<br>150 kHz to 10 MHz<br>Modulation Frequency<br>200 Hz to 10 kHz    | 0.15 Radians                                                                            |                        |
| $\Phi$ M Deviation:<br>$\leq 400$ Radians peak                                                                               | Carrier Frequency<br>10 MHz to 1.3 GHz<br>Modulation Frequency<br>200 Hz to 20 kHz    | 0.14 Radians                                                                            |                        |

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**SCOPE OF CALIBRATION: ELECTRICAL (RF)**

| Instrument Calibrated/<br>Measurement Parameter                                                            | Range                                                                                      | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks  |
|------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|----------|
| 2. Generating Instrument<br>Continue<br>DISTORTION<br>Related Signal:<br>Audio Distortion<br>(-99 to 0) dB | Fundamental Frequency<br>20 Hz to 20 kHz<br><br>Fundamental Frequency<br>20 kHz to 100 kHz | 1 dB<br><br>2 dB                                                                        | HP 8903B |

**SCOPE OF CALIBRATION: ELECTRICAL (RF)****SITE CALIBRATION: CATEGORY I**

| Instrument Calibrated/<br>Measurement<br>Parameter | Range                                      | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks                                   |
|----------------------------------------------------|--------------------------------------------|-----------------------------------------------------------------------------------------|-------------------------------------------|
| Signal Generator<br>FREQUENCY                      | 1 Hz to 5 GHz                              | 0.32 nHz/Hz                                                                             | HP53132A<br>Reference to<br>Pendulum 6689 |
| AMPLITUDE/ LEVEL                                   | -20 dBm to +30 dBm<br>(100 kHz to 2.6 GHz) | 0.04 dBm                                                                                | HP 8902 with<br>11722A                    |
|                                                    | -36 dB to +20 dB<br>9 kHz to 6 GHz)        | 38 mdBm/dBm + 5.3 mdBm                                                                  | Agilent E4418B with<br>E9304A             |
| TUNED RF LEVEL                                     | -127 dB to 0 dB<br>(2.5 MHz to 1.3 GHz)    | 0.07 dBm                                                                                | HP 8902 with<br>11722A                    |

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SCOPE OF CALIBRATION: ELECTRICAL (RF)

SITE CALIBRATION: CATEGORY I

| Instrument Calibrated/<br>Measurement<br>Parameter | Range                                                                                    | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks                                                                |
|----------------------------------------------------|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| Measuring Instrument<br><br>Frequency              | 1 $\mu$ Hz to 80 MHz<br>(10 mVpp to 10 Vpp)<br>250 kHz to 40 GHz<br>(+11 dBm to -135dBm) | 0.23 nHz/Hz + 0.67 mHz<br><br>5.2 nHz/Hz + 46 $\mu$ Hz                                  | (Agilent 33250A or<br>Agilent E8257D)<br>Reference to Pendulum<br>6689 |
| Amplitude                                          | 10 mVp-p to 10 Vp-p<br>(1 $\mu$ Hz to 80 MHz, Into 50 $\Omega$ )                         | 10 mVpp/Vpp + 1 mVpp                                                                    | Agilent 33250A                                                         |
| Flatness                                           | +11 dBm to -135dBm<br>(250 kHz to 40 GHz)                                                | 0.92 dBm                                                                                | Agilent E8257D                                                         |
|                                                    | Sine Wave Relative to 1 kHz<br>(Auto range on)                                           | 0.4 dBm                                                                                 | Agilent 33250A                                                         |

**Signatories:**

1. Mohamed Fikri Bin Mohd Nor
2. Syahrel Bin Shari

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## SCOPE OF CALIBRATION: TEMPERATURE

| Instrument Calibrated/<br>Measurement Parameter      | Range                                                                   | Calibration and<br>Measurement<br>Capability Expressed<br>as an Uncertainty ( $\pm$ ) * | Remarks                                                                                                                                                                              |
|------------------------------------------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Liquid In-glass Thermometer<br>(Partial Immersion)   | 0 °C to 200 °C                                                          | 2 °C                                                                                    | Comparison method<br>using SPRT / PRT in<br>liquid bath.                                                                                                                             |
| Liquid-in-glass thermometer<br>(Total Immersion)     | - 80 °C to 0 °C<br>0 °C to 80 °C<br>80 °C to 250 °C<br>250 °C to 500 °C | 0.05 °C<br>0.03 °C<br>0.05 °C<br>0.10 °C                                                | Comparison method<br>using SPRT / PRT in<br>liquid bath.                                                                                                                             |
| Platinum Resistance<br>Thermometer                   | - 80 °C to 600 °C<br>600 °C to 950 °C                                   | 0.05 °C<br>0.5 °C                                                                       | Comparison method<br>using SPRT / PRT in<br>liquid bath/dry block                                                                                                                    |
| Thermocouple                                         | - 80 °C to 600 °C<br>600 °C to 950 °C                                   | 0.1 °C<br>0.3 °C                                                                        | Comparison method<br>using SPRT/ PRT/<br>Standard Thermocouple<br>Type R liquid bath/dry<br>block                                                                                    |
| Psychrometer<br>Thermohygrograph<br>Thermohygrometer | 10 °C to 50 °C<br>35 % to 95 %RH                                        | 0.5 °C<br>3.0 %RH                                                                       | Comparison method<br>using:<br>1) PT100 sensor for wet<br>and dry bulb based<br>on BS1339-1: 2002<br>in climatic chamber<br>2) Temperature Humidity<br>Meter in Climatic<br>Chamber. |
| Temperature switch                                   | - 50 °C to 10 °C<br>10 °C to 100 °C<br>100 °C to 600 °C                 | 1 °C<br>2 °C<br>3 °C                                                                    | Comparison method<br>using SPRT/ PRT/<br>Thermocouple Type R in<br>liquid bath/dry block                                                                                             |
| Mechanical thermometer                               | - 80 °C to 100 °C<br>100 °C to 200 °C<br>200 °C to 600 °C               | 0.1 °C<br>0.6 °C<br>1.5 °C                                                              | Comparison method<br>using SPRT/ PRT/<br>Thermocouple Type R in<br>liquid bath/dry block                                                                                             |
| Temperature Calibrator<br>(Dry block)                | - 30 °C to 600 °C<br>600 °C to 950 °C                                   | 0.11 °C<br>0.63 °C                                                                      | EA-10 /13 (EAL<br>Guideline for calibration<br>of Dry block Calibrator)                                                                                                              |

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## SCOPE OF CALIBRATION: TEMPERATURE

| Instrument Calibrated/<br>Measurement Parameter | Range                                 | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks                                                                 |
|-------------------------------------------------|---------------------------------------|-----------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Temperature Indicating<br>Instruments           |                                       |                                                                                         |                                                                         |
| K - type                                        | - 200 °C to 0 °C<br>0 °C to 1300 °C   | 0.4 °C<br>0.4 °C                                                                        |                                                                         |
| J - type                                        | - 200 °C to 0 °C<br>0 °C to 1100 °C   | 0.3 °C<br>0.3 °C                                                                        |                                                                         |
| T - type                                        | - 200 °C to 0 °C<br>0 °C to 400 °C    | 0.5 °C<br>0.4 °C                                                                        |                                                                         |
| E - type                                        | - 200 °C to 0 °C<br>0 °C to 900 °C    | 0.4 °C<br>0.3 °C                                                                        |                                                                         |
| R – type                                        | 0 °C to 1000 °C<br>1000 °C to 1700 °C | 1.3 °C<br>1.1 °C                                                                        |                                                                         |
| S - type                                        | 0 °C to 1000 °C<br>1000 °C to 1700 °C | 1.3 °C<br>1.2 °C                                                                        |                                                                         |
| Pt 100                                          | - 200 °C to 0 °C<br>0 °C to 800 °C    | 0.2 °C<br>0.5 °C                                                                        |                                                                         |
|                                                 |                                       |                                                                                         | Calibration by Electrical<br>simulation using<br>Temperature Calibrator |

## Signatory:

1. Zulkifli Ahmad
2. Saleemullah Khan Anwar Khan

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**SCOPE OF CALIBRATION: TEMPERATURE****SITE CALIBRATION: CATEGORY I**

| Instrument Calibrated/<br>Measurement Parameter | Range                                                     | Calibration and<br>Measurement<br>Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks                                                                 |
|-------------------------------------------------|-----------------------------------------------------------|--------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Humidity Chamber                                | 20 % to 95 %RH                                            | 2.0 % of RH                                                                                | TLAS-G-20<br>BS 1339-1 :2002                                            |
| Temperature Controlled<br>Enclosure             | - 60 °C to 200 °C<br>200 °C to 400 °C<br>400 °C to 950 °C | 0.8 °C<br>1.2 °C<br>2 °C                                                                   | TLAS-G-20                                                               |
| Temperature Indicating<br>Instruments           |                                                           |                                                                                            |                                                                         |
| K - type                                        | - 200 °C to 0 °C<br>0 °C to 1300 °C                       | 0.4 °C<br>0.4 °C                                                                           | Calibration by Electrical<br>simulation using<br>Temperature Calibrator |
| J - type                                        | - 200 °C to 0 °C<br>0 °C to 1100 °C                       | 0.3 °C<br>0.3 °C                                                                           |                                                                         |
| T - type                                        | - 200 °C to 0 °C<br>0 °C to 400 °C                        | 0.5 °C<br>0.4 °C                                                                           |                                                                         |
| E - type                                        | - 200 °C to 0 °C<br>0 °C to 900 °C                        | 0.4 °C<br>0.3 °C                                                                           |                                                                         |
| R – type                                        | 0 °C to 1000 °C<br>1000 °C to 1700 °C                     | 1.3 °C<br>1.1 °C                                                                           |                                                                         |
| S - type                                        | 0 °C to 1000 °C<br>1000 °C to 1700 °C                     | 1.3 °C<br>1.2 °C                                                                           |                                                                         |
| Pt 100                                          | - 200 °C to 0 °C<br>0 °C to 800 °C                        | 0.2 °C<br>0.5 °C                                                                           |                                                                         |

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1. Zulkifli Ahmad
2. Saleemullah Khan Anwar Khan



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**SCOPE OF CALIBRATION: TEMPERATURE****SITE CALIBRATION: CATEGORY I**

| Instrument Calibrated/<br>Measurement Parameter | Range            | Calibration and<br>Measurement<br>Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks                                                                                  |
|-------------------------------------------------|------------------|--------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Temperature Sensor with<br>Indicator<br>-PT100  | 0 °C to 300 °C   | 0.15 °C                                                                                    | Calibration by<br>comparison method<br>using:                                            |
|                                                 | 301 °C to 600 °C | 0.26 °C                                                                                    |                                                                                          |
| -Thermocouple                                   | 0 °C to 300 °C   | 0.15 °C                                                                                    | 1-Pt100 / Type R<br>Thermocouple as<br>reference standards<br><br>2-Dry Block Calibrator |
|                                                 | 301 °C to 600 °C | 0.26 °C                                                                                    |                                                                                          |
|                                                 | 601 °C to 950 °C | 1.1 °C                                                                                     |                                                                                          |

**Signatories:**

1. **Zulkifli Ahmad**
2. **Saleemullah Khan Anwar Khan**

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## SCOPE OF CALIBRATION: DIMENSIONAL

| Instrument Calibrated/<br>Measurement Parameter                                 | Range                                                       | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks                              |
|---------------------------------------------------------------------------------|-------------------------------------------------------------|-----------------------------------------------------------------------------------------|--------------------------------------|
| Gauge Block                                                                     | 0.5 mm to 100 mm<br>100 mm to 250 mm                        | $(0.1 + 1.0 L) \mu\text{m}$<br>L in m                                                   | Reference Equipment:<br>Gauge block  |
| Gauge Block<br>(Imperial units)                                                 | 0.05 inch to 4 inch                                         | $(0.004 + 1.0 L) \mu\text{inch}$<br>L in inch                                           | Gauge block                          |
| Bevel Protractor                                                                | 0 to 360 degrees:<br>Graduation 5 min.<br>Graduation 1 deg. | 3 minute<br>0.5 degree                                                                  | Angle block                          |
| Snap Gauge / Caliper<br>Gauge                                                   | Up to 200 mm                                                | 5 $\mu\text{m}$                                                                         | Uni. Measuring M/c                   |
| Micrometer<br>25 mm travels for frame<br>Sizes 25 mm, 50 mm, 75<br>mm and 100mm | 0.001 mm to 100 mm                                          | 2 $\mu\text{m}$                                                                         | Gauge Block                          |
| Caliper                                                                         | 0.01 mm to 300 mm<br>300 mm to 600 mm<br>600 mm to 1000 mm  | 7 $\mu\text{m}$<br>9 $\mu\text{m}$<br>12 $\mu\text{m}$                                  | Gauge Block<br>Caliper Checker       |
| Height Gauge                                                                    | 0.01 mm to 600 mm                                           | 10 $\mu\text{m}$                                                                        | Caliper Checker                      |
| Caliper Checker                                                                 | 20 mm to 300 mm<br>301 mm to 600 mm                         | 3 $\mu\text{m}$<br>9 $\mu\text{m}$                                                      | Long Gauge block                     |
| Calibration Tester                                                              | 0 mm to 25 mm                                               | 2 $\mu\text{m}$                                                                         | Dig.Length Indicator<br>/Gauge Block |
| Dial / Digital Test Indicator                                                   | 0.001 mm to 100 mm                                          | 2 $\mu\text{m}$                                                                         | Dial gauge testing machine           |
| Dial / Digital Gauge                                                            | 0.001 mm to 100 mm                                          | 2 $\mu\text{m}$                                                                         | Dial gauge testing machine           |
| Dial / Digital Thickness<br>Gauge                                               | 0.01 mm to 50 mm                                            | 5 $\mu\text{m}$                                                                         | Gauge Block                          |
| Depth Micro-Checker                                                             | 0 mm to 300 mm                                              | 6 $\mu\text{m}$                                                                         | Gauge Block / Pre. Height<br>Gauge   |

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## SCOPE OF CALIBRATION: DIMENSIONAL

| Instrument Calibrated/<br>Measurement Parameter    | Range                               | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) *  | Remarks                                       |
|----------------------------------------------------|-------------------------------------|------------------------------------------------------------------------------------------|-----------------------------------------------|
| Feeler Gauge                                       | 0.005 mm to 2.0 mm                  | 3 $\mu$ m                                                                                | Dig. Length Indicator                         |
| Glass Scale                                        | up to 200 mm<br>200 mm to 300 mm    | 3.8 $\mu$ m<br>5.6 $\mu$ m                                                               | Uni. Measuring M/c                            |
| Grind Gauge/Fine Gauge                             | 0.001 mm to 0.15 mm                 | 2 $\mu$ m                                                                                | Dig. Length Indicator                         |
| Height master                                      | 0.001 mm to 600 mm                  | 6 $\mu$ m                                                                                | Pre. Height Gauge / Gauge Block               |
| Ruler                                              | 0.1 mm to 2000 mm                   | 0.1 mm                                                                                   | Linear scale                                  |
| Mu-checker                                         | 0.1 mm to 2000 $\mu$ m              | 2 $\mu$ m                                                                                | Gauge Block                                   |
| Precision Height Gauge                             | 0.001 mm to 600 mm                  | 4 $\mu$ m                                                                                | Gauge Block                                   |
| Straight Edge                                      | 0 mm to 600 mm                      | 1.5 $\mu$ m                                                                              | Dig.Length Indicator /<br>Straight edge       |
| Tape                                               | 0 m to 100 m                        | (0.33 + 0.019 L) mm<br><i>L is length in unit meter</i>                                  | Linear scale                                  |
| Thickness Foil                                     | 0.001 mm to 2.0 mm                  | 3 $\mu$ m                                                                                | Dig.Length Indicator                          |
| Setting/Standard Rod                               | 25 mm to 100 mm<br>100 mm to 600 mm | (0.15 + 0.0064 L)<br>(0.11 + 0.008 L)<br><i>L is length in unit mm</i>                   | Universal Length Machine<br>and Gauge Block   |
| Plain Pin or Plug Gauge<br>(Diameter Only)         | 0.2 mm to 50 mm                     | 0.5 $\mu$ m                                                                              | Universal Length Machine                      |
| Plain Ring Gauge<br>(Diameter Only)                | 1 mm to 100 mm<br>100 mm to 200 mm  | (0.007 L + 0.11) $\mu$ m<br>(0.0064 L + 0.41) $\mu$ m<br><i>L is diameter in unit mm</i> | Universal Length Machine<br>and Gauge Block   |
| Thread Plug Gauge<br>(Simple Pitch Diameter)       | 2 mm to 50 mm                       | 2 $\mu$ m                                                                                | Universal Length Machine<br>(In-house Method) |
| Length Machine<br>(For in-house equipment<br>only) | 0 mm to 1 m<br>0 mm to 10 m         | 0.1 mm<br>0.4 mm                                                                         | Standard Scale                                |

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## SCOPE OF CALIBRATION: DIMENSIONAL

| Instrument Calibrated/<br>Measurement Parameter                                                                | Range          | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks        |
|----------------------------------------------------------------------------------------------------------------|----------------|-----------------------------------------------------------------------------------------|----------------|
| Universal Measuring<br>Microscope<br>(Individual linear axis only-<br><i>For in-house equipment<br/>only</i> ) | 0 mm to 200 mm | 2.5 $\mu$ m                                                                             | Standard Scale |
| Digital Length Indicator                                                                                       | 0 to 25 mm     | 0.4 $\mu$ m                                                                             | Gauge Block    |

## Signatories:

1. Mohd Hashim Effandi
2. Mohd Amri Abd Aziz

NO: SAMM 088

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SCOPE OF CALIBRATION: DIMENSIONAL

SITE CALIBRATION: CATEGORY I

| Instrument Calibrated/<br>Measurement Parameter                   | Range             | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks              |
|-------------------------------------------------------------------|-------------------|-----------------------------------------------------------------------------------------|----------------------|
| Profile Projector<br>(Error of indication of<br>linear scale X-Y) | 1 mm to 200 mm    | 5 $\mu$ m                                                                               | Glass Scale          |
|                                                                   | 201 mm to 300 mm  | 7 $\mu$ m                                                                               |                      |
| Surface Table/Plate                                               | 2500 mm x 1600 mm | 4 $\mu$ m                                                                               | Levelnic / Plankator |

**Signatories:**

1. Mohd Hashim Effandi
2. Mohd Amri Abd Aziz

NO: SAMM 088

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## SCOPE OF CALIBRATION: MASS

| Instrument Calibrated/<br>Measurement Parameter      | Range                                                                                                                                                                                                                                                                                                                                                    | Calibration and<br>Measurement Capability<br>Expressed as an Uncertainty<br>( $\pm$ ) *                                                                                                                                                                            | Remarks                                                                                                                                                                                     |
|------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Standard Weights<br>Class E2, F1, F2, M1, M2<br>& M3 | 1 mg<br>2 mg<br>5 mg<br>10 mg<br>20 mg<br>50 mg<br>100 mg<br>200 mg<br>500 mg<br>1 g<br>2 g<br>5 g<br>10 g<br>20 g<br>50 g<br>100 g<br>200 g<br>500 g<br>1 kg<br>2 kg<br>5 kg<br>10 kg<br>20 kg                                                                                                                                                          | 0.002 mg<br>0.002 mg<br>0.003 mg<br>0.003 mg<br>0.003 mg<br>0.004 mg<br>0.005 mg<br>0.006 mg<br>0.008 mg<br>0.010 mg<br>0.012 mg<br>0.016 mg<br>0.020 mg<br>0.026 mg<br>0.04 mg<br>0.05 mg<br>0.10 mg<br>0.26 mg<br>0.51 mg<br>1.3 mg<br>3.0 mg<br>16 mg<br>100 mg | With general reference to OIML R111. Mass comparison using: ABBA weighing scheme for weights of OIML classes E2 and F1; and AB, AB weighing scheme for weights of OIML classes F2 and below |
| Weight Blocks                                        | 1 mg to 10 g<br>Above 10 g to 50 g<br>Above 50 g to 100 g<br>Above 100 g to 200 g<br>Above 200 g to 500 g<br>Above 500 g to 1 kg<br>Above 1 kg to 2 kg<br>Above 2 kg to 5 kg<br>Above 5 kg to 10 kg<br>Above 10 kg to 20 kg<br>Above 20 kg to 30 kg<br>Above 30 kg to 60 kg<br>Above 60 kg to 100 kg<br>Above 100 kg to 200 kg<br>Above 200 kg to 500 kg | 2 mg<br>3 mg<br>5 mg<br>9 mg<br>0.02 g<br>0.05 g<br>0.09 g<br>0.2 g<br>0.5 g<br>0.9 g<br>1.3 g<br>2.6 g<br>0.02 kg<br>0.02 kg<br>0.04 kg                                                                                                                           | Mass comparison using AB, AB weighing scheme                                                                                                                                                |

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## SCOPE OF CALIBRATION: MASS

| Instrument Calibrated/<br>Measurement Parameter | Range                                                    | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) * | Remarks                                                    |
|-------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------------------------------------|------------------------------------------------------------|
| Spring /Hanging Scale                           | up to 5 kg<br>up to 20 kg<br>up to 50 kg<br>up to 100 kg | 16 g<br>31 g<br>62 g<br>0.13 kg                                                         | Using calibrated<br>standard weights of<br>OIML classes F1 |

## Signatories:

1. Mohammad Najib Kamaruddin
2. Mohd Suhaili Bahrom

NO: SAMM 088

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SCOPE OF CALIBRATION: **MASS**SITE CALIBRATION: **CATEGORY I**

| Instrument Calibrated/<br>Measurement Parameter                                              | Range                                                                                                                                       | Calibration and<br>Measurement Capability<br>Expressed as an Uncertainty<br>( $\pm$ ) * | Remarks                                       |
|----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|-----------------------------------------------|
| Analytical Balance                                                                           | up to 50 g<br>up to 100 g<br>up to 200 g                                                                                                    | 0.13 mg<br>0.15 mg<br>0.2 mg                                                            | OIML class E2<br>Reference Weights            |
| Balance / Scale<br>(Triple Beam, Single<br>Beam Spring, Top Pan,<br>Mechanical & Electronic) | up to 1000 g<br>up to 2000 g<br>up to 5000 g<br>up to 10000 g<br>up to 20 kg<br>up to 50 kg<br>up to 100 kg<br>up to 200 kg<br>up to 500 kg | 2 mg<br>0.02 g<br>0.02 g<br>0.2 g<br>0.2 g<br>2 g<br>13 g<br>0.03 kg<br>0.1 kg          | OIML classes<br>F1/F2/M2<br>Reference Weights |
| Electrical and Mechanical<br>Platform Balance                                                | up to 1000 kg<br><br>up to 2000 kg                                                                                                          | 0.27 kg<br><br>0.66 kg                                                                  | OIML class M2<br>Reference Weights            |

**Signatories:**

1. **Mohammad Najib Kamaruddin**
2. **Mohd Suhaili Bahrom**



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**SCOPES OF CALIBRATION: FORCE & TORQUE**

| Instrument Calibrated/<br>Measurement Parameter | Range                                                                                   | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks                                                                                                                                             |
|-------------------------------------------------|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>FORCE MEASUREMENT</b>                        |                                                                                         |                                                                                        |                                                                                                                                                     |
| Proving Rings/Load Cells                        | (0 – 5000) N<br>(5001-10000) N<br>(10.1 – 50) KN<br>(50.1 – 100) KN<br>(100.1 – 300) KN | 2.2 N<br>1.0 N<br>0.12 KN<br>0.20 KN<br>1.7 KN                                         | Calibrated by using Load Cell with reference to ISO 376: 2011                                                                                       |
| Push-pull/ Force Gauge                          | 1 gf to 5 kgf<br>5 kgf to 20 kgf<br>20 kgf to 50 kgf<br>50 kgf to 100 kgf               | 16 gf<br>31 gf<br>62 gf<br>124 gf                                                      | ASTM E74-18<br>Using Standard Weight Class F1 & F2                                                                                                  |
| Gramme/ Dial Tension Gauge                      | 1 gf to 50 gf<br>50 gf to 500 gf<br>500 gf to 2000 gf                                   | 1 gf<br>6 gf<br>30 gf                                                                  | ASTM E74-18<br>Using Standard Weight Class F1 & F2                                                                                                  |
| <b>TORQUE MEASUREMENT</b>                       |                                                                                         |                                                                                        |                                                                                                                                                     |
| Torque wrench                                   | 0 N.m to 2 N.m<br>2.1 N.m to 100 N.m<br>101 N.m to 500 N.m                              | 0.07 N.m<br>0.3 N.m<br>2 N.m                                                           | Comparison with torque transducers with general reference to BS EN ISO 6789-1:2017<br>Transducer 2 N.m<br>Transducer 100 N.m<br>Transducer 1000 N.m |
| Torque meter and analyser                       | 0 N.m to 2 N.m<br>3 N.m to 50 N.m<br>51 N.m to 100 N.m<br>101 N.m to 500 N.m            | 0.1% of reading<br>0.1% of reading<br>0.1% of reading<br>0.1% of reading               | With general reference to BS 7882: 2017                                                                                                             |

**Signatories:**

1. Muhamad Saiful Jamaludin
2. Murali A/L Subramaniam (Non-Resident Signatory) – Excluding Torque Measurement

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SCOPE OF CALIBRATION: FORCE

SITE CALIBRATION: CATEGORY I

| Instrument Calibrated/<br>Measurement Parameter | Range                                                                                                                             | Calibration and<br>Measurement<br>Capability Expressed<br>as an Uncertainty ( $\pm$ )* | Remarks                                                                            |
|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Universal Testing Machine /<br>Compression mode | (0 -5000) N<br>(5001 – 10000) N<br>(10.1 – 50) KN<br>(50.1 – 100) KN<br>(100.1 – 600) KN<br>(600.1 – 900) KN<br>(900.1 – 1800) KN | 2.2 N<br>1.0 N<br>0.12 KN<br>0.20 KN<br>0.12 KN<br>2.51 KN<br>2.58 KN                  | Calibrated by using<br>load cell with<br>reference to<br>BS EN ISO 7500-<br>1:2018 |
| Charpy / Izod Impact Tester                     | 1 Joule to 300 Joules                                                                                                             | 1 % of reading                                                                         | BS 131-7: 1998                                                                     |

**Signatories:**

1. Muhamad Saiful Jamaludin
2. Murali A/L Subramaniam (Non-Resident Signatory)

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**SCOPE OF CALIBRATION: PRESSURE**

| Instrument Calibrated/<br>Measurement Parameter        | Range                                                          | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks                                                                                                                                  |
|--------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Pressure measuring device<br>(Gas medium)              | 1 psi to 100 psi<br>101 psi to 1600 psi                        | 0.02 % of pressure<br>0.02 % of pressure                                               | Comparison with Dead<br>Weight Tester with<br>reference to BS EN 837-<br>1: 1998 and<br>837-2, 837-3: 1998<br>ADWT<br>ADWT               |
| Pressure measuring device<br>(Oil and water medium)    | 10 psi to 800 psi<br>801 psi to 16000 psi                      | 0.02 % of pressure<br>0.02 % of pressure                                               | DWT<br>DWT                                                                                                                               |
|                                                        | 16 001 psi to 40000 psi                                        | 0.02 % of pressure                                                                     | With reference to<br>BS EN 837-1: 1998<br>BS EN 837-3: 1998                                                                              |
| Vacuum gauge                                           | Ambient to<br>-0.9 bar (Gauge mode)<br>0.1 bar (Absolute mode) | 0.1 % of pressure                                                                      | Mercury Manometer<br>Multifunction Calibrator                                                                                            |
| Low Pressure Measuring<br>Devices<br>Mercury Manometer | 0 to 1500 mm Hg                                                | 0.02 % of pressure                                                                     | Digital Manometer<br>Reference Pressure<br>Balance                                                                                       |
| Deadweight Tester                                      | 10 psi to 40 000 psi                                           | 0.02 % of pressure                                                                     | Cross float method with<br>reference to<br>OIML R110 1994(E)<br>NCSL RISP-4 2000<br>EAL G26/EA-4/17 JULY<br>1997<br><br>Pressure Balance |

Note: ADWT (Air Dead Weight Tester)  
DWT (Dead Weight Tester)

**Signatories:**

1. Muhamad Saiful Jamaludin
2. Muhammad Azri Bahari
3. Murali A/L Subramaniam (Non-Resident Signatory)

NO: SAMM 088

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**SCOPE OF CALIBRATION: PRESSURE****SITE CALIBRATION: CATEGORY I**

| Instrument Calibrated/<br>Measurement Parameter | Range                                                                                                      | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )*                | Remarks                                                                                                   |
|-------------------------------------------------|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| Pressure measuring device<br>(Oil medium)       | 0 psi to 100 psi<br>0 psi to 1000 psi<br>0 psi to 10 000 psi<br>0 psi to 12 000 psi<br>0 psi to 16 000 psi | 0.3 % of pressure<br>0.4 % of pressure<br>0.5 % of pressure<br>0.6 % of pressure<br>0.6 % of pressure | Calibrate with<br>reference to<br>BS EN 837-1: 1998<br>BS EN 837-3: 1998<br><br>DWT<br>Digital Test Gauge |
| Vacuum Measuring<br>Devices                     | Ambient to<br>-0.9 bar (Gauge mode)<br>0.1 bar (Absolute mode)                                             | 1.0 % of pressure                                                                                     | Calibrate by using<br>Pressure Calibrator<br>with reference to<br>BS EN 837-1: 1998<br>BS EN 837-3: 1998  |
| Pressure Gauge                                  | 0 bar to 20 bar                                                                                            | 0.5 % of pressure                                                                                     | Calibrate by using<br>Pressure Calibrator<br>with reference to<br>BS EN 837-1: 1998<br>BS EN 837-3: 1998  |

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**SCOPE OF CALIBRATION: VOLUMETRIC**

| Instrument Calibrated/<br>Measurement Parameter | Range                                                                                                                                                                                                                                                          | Calibration and<br>Measurement<br>Capability Expressed<br>as an Uncertainty ( $\pm$ )*                                               | Remarks                                               |
|-------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
| Bulb Pipette                                    | 1 ml to 5 ml<br>5 ml to 100 ml                                                                                                                                                                                                                                 | 0.008 ml<br>0.03 ml                                                                                                                  | Cal. Procedure No<br>TCP 0002 REV2.0<br>Ref: ISO 4787 |
| Graduated Pipette                               | 1 ml to 5 ml<br>5 ml to 100 ml                                                                                                                                                                                                                                 | 0.008 ml<br>0.03 ml                                                                                                                  | Cal. Procedure No<br>TCP 0002 REV2.0<br>Ref: ISO 4787 |
| Measuring Cylinder                              | 5 ml to 100 ml<br>100 ml to 500 ml<br>500 ml to 1000 ml<br>1000 ml to 2000 ml                                                                                                                                                                                  | 0.05 ml<br>0.5 ml<br>2.0 ml<br>3.0 ml                                                                                                | Cal. Procedure No<br>TCP 0001 REV2.0<br>Ref: ISO 4787 |
| Burette                                         | 1 ml to 50 ml                                                                                                                                                                                                                                                  | 0.05 ml                                                                                                                              | Cal. Procedure No<br>TCP 0003 REV2.0<br>Ref: ISO 4787 |
| Beaker & Flasks                                 | 5 ml to 100 ml<br>100 ml to 1000 ml<br>1000 ml to 2000 ml                                                                                                                                                                                                      | 1.0 ml<br>3.0 ml<br>5.0 ml                                                                                                           | Cal. Procedure No<br>TCP 0004 REV2.0<br>Ref: ISO 4787 |
| Piston-operated Volumetric<br>apparatus         | 10 $\mu$ l to 20 $\mu$ l<br>20 $\mu$ l to 50 $\mu$ l<br>50 $\mu$ l to 100 $\mu$ l<br>100 $\mu$ l to 200 $\mu$ l<br>200 $\mu$ l to 500 $\mu$ l<br>500 $\mu$ l to 1000 $\mu$ l<br>1000 $\mu$ l to 5000 $\mu$ l<br>5000 $\mu$ l to 10000 $\mu$ l<br>10000 $\mu$ l | 0.03 $\mu$ l<br>0.09 $\mu$ l<br>0.15 $\mu$ l<br>0.4 $\mu$ l<br>0.8 $\mu$ l<br>1.8 $\mu$ l<br>3.5 $\mu$ l<br>20 $\mu$ l<br>40 $\mu$ l | No.TCP/0005 REV.0.0<br>Based on ISO 8655-<br>6:2002   |

**Signatories:**

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2. Mohamad Yati A. Rahman

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## SCOPE OF CALIBRATION: HYDROMETER

| Instrument Calibrated/<br>Measurement Parameter | Range                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks                                                  |
|-------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------|
| Density Hydrometer                              | 0.600 g/ml to 0.650 g/ml<br>0.650 g/ml to 0.700 g/ml<br><br>0.700 g/ml to 0.750 g/ml<br>0.750 g/ml to 0.800 g/ml<br><br>0.800 g/ml to 0.850 g/ml<br>0.850 g/ml to 0.900 g/ml<br><br>0.900 g/ml to 0.950 g/ml<br>0.950 g/ml to 1.000 g/ml<br><br>1.000 g/ml to 1.050 g/ml<br>1.050 g/ml to 1.100 g/ml<br><br>1.100 g/ml to 1.150 g/ml<br>1.150 g/ml to 1.200 g/ml<br><br>1.200 g/ml to 1.250 g/ml<br>1.250 g/ml to 1.300 g/ml<br><br>1.300 g/ml to 1.350 g/ml<br>1.350 g/ml to 1.400 g/ml<br><br>1.400 g/ml to 1.450 g/ml<br>1.450 g/ml to 1.500 g/ml | 0.001 g/ml<br>(resolution 0.0005 g/ml)                                                 | Comparison<br>Method with<br>reference to<br>BS 718:1991 |

## Signatories:

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2. Mohamad Yati A. Rahman

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## SCOPE OF CALIBRATION:

## HYDROMETER

| Instrument Calibrated/<br>Measurement Parameter   | Range                                                                                                                                                                                  | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks                                                            |
|---------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| Temperature<br><br>Specific Gravity<br>Hydrometer | 0.6 to 0.65<br>0.65 to 0.7<br>0.7 to 0.75<br>0.75 to 0.8<br>0.8 to 0.85<br>0.85 to 0.9<br>0.9 to 0.95<br>0.95 to 1<br>1 to 1.1<br>1.1 to 1.2<br>1.2 to 1.3<br>1.3 to 1.4<br>1.4 to 1.5 | 0.001<br>(resolution 0.0005)                                                           | Cal. Procedure No.<br>MDL 0002 with<br>reference to BS<br>718:1991 |

## Signatories:

1. Mohammad Najib Kamaruddin
2. Mohamad Yati A. Rahman

NO: SAMM 088

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## SCOPE OF CALIBRATION:

## ACOUSTIC &amp; VIBRATION

| Instrument Calibrated/<br>Measurement Parameter           | Range                                                                                                                                                                                  | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks                                                                                                                                                                                                   |
|-----------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Measuring Instrument<br><br>Sound Level Meter             | Nominal SPL<br>94 dB, 104 dB & 114 dB<br>Reference<br>94 dB re 20 $\mu$ Pa at 1 kHz<br><br>31.5 Hz to 16000 Hz<br><br>124 dB<br>(at 250Hz)<br><br>(54 to 134) dB<br>(31.5 to 12500) Hz | <br><br><br>0.98 mdB/dB - 0.13 dB<br><br>0.21 dB<br><br>0.13 dB                        | <br><br><br>Generating using<br>Bruel & Kjaer 4226<br><br><br>Generating using<br>Bruel & Kjaer 4228<br><br>Electrical Signal<br>Injection from<br>function generator<br>Agilent 33250A                   |
| Sourcing/Generating<br>Instrument<br><br>Sound Calibrator | Nominal SPL<br>94dB, 104 dB & 114 dB<br>Reference<br>94 dB re 20 $\mu$ Pa at 1 kHz<br><br>31.5 Hz to 16000 Hz<br><br>124 dB<br>(at 250Hz)                                              | <br><br><br>0.11 dB<br><br>0.21 dB                                                     | <br><br><br>Comparison with<br>reference<br>Calibrator Bruel &<br>Kjaer 4226 and<br>4231, Agilent<br>34401A<br><br>Comparison with<br>reference<br>Calibrator Bruel &<br>Kjaer 4228 and<br>Agilent 34401A |

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## Signatories:

1. Mohamed Fikri Bin Mohd Nor
2. Syahrel Bin Shari



NO: SAMM 088

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**SCOPE OF CALIBRATION: ACOUSTIC & VIBRATION****SCOPE OF ACCREDITATION: CATEGORY I**

| Instrument Calibrated/<br>Measurement Parameter           | Range                                                                                                                                                                                  | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks                                                                                                                                                                                               |
|-----------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Measuring Instrument<br><br>Sound Level Meter             | Nominal SPL<br>94 dB, 104 dB & 114 dB<br>Reference<br>94 dB re 20 $\mu$ Pa at 1 kHz<br><br>31.5 Hz to 16000 Hz<br><br>124 dB<br>(at 250Hz)<br><br>(54 to 134) dB<br>(31.5 to 12500) Hz | <br><br><br>0.98 mdB/dB - 0.13 dB<br><br>0.21 dB<br><br>0.13 dB                        | <br><br>Generating using<br>Briel & Kjaer 4226<br><br><br>Generating using<br>Briel & Kjaer 4228<br><br>Electrical Signal<br>Injection from<br>function generator<br>Agilent 33250A                   |
| Sourcing/Generating<br>Instrument<br><br>Sound Calibrator | Nominal SPL<br>94dB, 104 dB & 114 dB<br>Reference<br>94 dB re 20 $\mu$ Pa at 1 kHz<br><br>31.5 Hz to 1600 Hz<br><br>124 dB<br>(at 250Hz)                                               | <br><br><br>0.11 dB<br><br>0.21 dB                                                     | <br><br>Comparison with<br>reference<br>Calibrator Briel &<br>Kjaer 4226 and<br>4231, Agilent<br>34401A<br><br>Comparison with<br>reference<br>Calibrator Briel &<br>Kjaer 4228 and<br>Agilent 34401A |

**Signatories:**

- \*\*Mohamed Fikri Bin Mohd Nor**
- Syahrel Bin Shari**

\*\* Non-resident signatory

NO: SAMM 088

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## SCOPE OF CALIBRATION: TIME &amp; FREQUENCY

| Instrument Calibrated/<br>Measurement<br>Parameter                | Range                                                                                                                                                                                                                            | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) *                                              | Remarks                                                 |
|-------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| 1. Measuring Instrument<br><br>TIME                               | 1 s to 24 Hrs                                                                                                                                                                                                                    | 0.06 $\mu$ s/s + 0.021 s                                                                                                             | Agilent 33250A &<br>Universal Counter HP<br>53132A      |
|                                                                   | 20 ms to 5 s                                                                                                                                                                                                                     | 0.7 ms                                                                                                                               | For RCD Tester<br>Calibrator<br>(using Transmille 3200) |
| Residual Current<br>Duration                                      | 10 ms to 5 s                                                                                                                                                                                                                     | 0.4 ms                                                                                                                               |                                                         |
| RPM Measuring<br>Instruments (Non<br>Contact)                     | (60 to 5999) rpm<br>(6000 to 29999) rpm<br>(30000 to 59999) rpm<br>(60000 to 99999) rpm                                                                                                                                          | 13 $\mu$ rpm/rpm + 9.3 mrpm<br>31 $\mu$ rpm/rpm - 66 mrpm<br>0.36 prpm/rpm + 0.72 rpm<br>0.62 prpm/rpm + 0.72 rpm                    | In-House method,<br>ESF/0303                            |
| 2. Generating instrument<br><br>RPM<br>Non-Contact<br>Measurement | 10 to 29 rpm<br>30 to 59 rpm<br>60 to 99 rpm<br>100 to 299 rpm<br>300 to 599 rpm<br>600 to 999 rpm<br>1000 to 2999 rpm<br>3000 to 5999 rpm<br>6000 to 9999 rpm<br>10000 to 29999 rpm<br>30000 to 59999 rpm<br>60000 to 99999 rpm | 0.014 rpm<br>0.036 rpm<br>0.07 rpm<br>0.14 rpm<br>0.37 rpm<br>0.7 rpm<br>1.4 rpm<br>3.6 rpm<br>7 rpm<br>14 rpm<br>36 rpm<br>70 rpm   | In-House method,<br>ESF/0303                            |
| Contact Measurement                                               | 20 to 29 rpm<br>30 to 59 rpm<br>60 to 99 rpm<br>100 to 299 rpm<br>300 to 599 rpm<br>600 to 999 rpm<br>1000 to 2999 rpm<br>3000 to 5999 rpm<br>6000 to 9999 rpm<br>10000 to 12999 rpm<br>13000 to 25999 rpm<br>26000 to 29999 rpm | 0.011 rpm<br>0.016 rpm<br>0.029 rpm<br>0.07 rpm<br>0.16 rpm<br>0.29 rpm<br>0.7 rpm<br>1.6 rpm<br>2.9 rpm<br>7 rpm<br>8 rpm<br>14 rpm |                                                         |

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**SCOPE OF CALIBRATION: TIME & FREQUENCY****SITE CALIBRATION: CATEGORY I**

| Instrument Calibrated/<br>Measurement Parameter                    | Range                                                                                                                                                                                                                            | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) *                                            | Remarks                                                          |
|--------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| 1. Measuring Instrument<br><br>TIME                                | 1 s to 24 Hrs                                                                                                                                                                                                                    | 0.06 $\mu$ s/s + 0.021 s                                                                                                           | Agilent<br>33250A &<br>Universal<br>Counter HP<br>53132A         |
|                                                                    | 20 ms to 5 s                                                                                                                                                                                                                     | 0.7 ms                                                                                                                             | For RCD<br>Tester<br>Calibrator<br>(using<br>Transmille<br>3200) |
| Residual Current Duration                                          | 10 ms to 5 s                                                                                                                                                                                                                     | 0.4 ms                                                                                                                             |                                                                  |
| RPM Measuring<br>Instruments (Non<br>Contact)                      | (60 to 5999) rpm<br>(6000 to 29999) rpm<br>(30000 to 59999) rpm<br>(60000 to 99999) rpm                                                                                                                                          | 13 $\mu$ rpm/rpm + 9.3 mrpm<br>32 $\mu$ rpm/rpm - 66 mrpm<br>2.2 nrpm/rpm + 0.72 rpm<br>3.4 nrpm/rpm + 0.72 rpm                    | In-House<br>method,<br>ESF/0303                                  |
| 2. Generating Instrument<br>Continue<br><br>RPM (Non-Contact Type) | 10 to 29 rpm<br>30 to 59 rpm<br>60 to 99 rpm<br>100 to 299 rpm<br>300 to 599 rpm<br>600 to 999 rpm<br>1000 to 2999 rpm<br>3000 to 5999 rpm<br>6000 to 9999 rpm<br>10000 to 29999 rpm<br>30000 to 59999 rpm<br>60000 to 99999 rpm | 0.014 rpm<br>0.036 rpm<br>0.07 rpm<br>0.14 rpm<br>0.37 rpm<br>0.7 rpm<br>1.4 rpm<br>3.6 rpm<br>7 rpm<br>14 rpm<br>36 rpm<br>70 rpm | In-House<br>method,<br>ESF/0303.                                 |

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**SCOPE OF CALIBRATION: TIME & FREQUENCY****SITE CALIBRATION: CATEGORY I**

| Instrument Calibrated/<br>Measurement Parameter | Range                                                                                                                                                                                                                            | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ ) *                                              | Remarks                          |
|-------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| RPM (Contact Type)                              | 20 to 29 rpm<br>30 to 59 rpm<br>60 to 99 rpm<br>100 to 299 rpm<br>300 to 599 rpm<br>600 to 999 rpm<br>1000 to 2999 rpm<br>3000 to 5999 rpm<br>6000 to 9999 rpm<br>10000 to 12999 rpm<br>13000 to 25999 rpm<br>26000 to 29999 rpm | 0.011 rpm<br>0.016 rpm<br>0.029 rpm<br>0.07 rpm<br>0.16 rpm<br>0.29 rpm<br>0.7 rpm<br>1.6 rpm<br>2.9 rpm<br>7 rpm<br>8 rpm<br>14 rpm | In-House<br>method,<br>ESF/0303. |

**Signatories:**

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2. Syahrel Bin Shari

**NO: SAMM 088**

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**LABORATORY LOCATION:**  
(BRANCH LABORATORY)

**SIRIM CALIBRATION SDN. BHD.**  
**(Company No.: 292201-P)**  
**BANGUNAN SIRIM BERHAD,**  
**JALAN PINTASAN KUANTAN– KUALA TERENGGANU,**  
**KAWASAN PERINDUSTRIAN GEBENG**  
**26100 KUANTAN.**  
**PAHANG DARUL MAKMUR.**  
**MALAYSIA**

### FEILDS OF CALIBRATION:

## ELECTRICAL & PRESSURE

**SCOPE OF CALIBRATION:**

## ELECTRICAL

| Instrument Calibrated/<br>Measurement Parameter     | Range                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Remarks                                            |                                      |
|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|--------------------------------------|
| 1.Measuring Instruments<br>(a) DC Voltage ( $\pm$ ) | 0 mV to 330 mV<br>0 V to 3.3 V<br>0 V to 33 V<br>30 V to 330 V<br>100 V to 1020 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 22 $\mu$ V/V + 1.8 $\mu$ V<br>11 $\mu$ V/V + 9.9 $\mu$ V<br>12 $\mu$ V/V + 96 $\mu$ V<br>23 $\mu$ V/V + 0.98 mV<br>23 $\mu$ V/V + 5.4 mV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Generate using<br>calibrator model<br>Fluke 5522 A |                                      |
| (b) Resistance                                      | 0 $\Omega$ to 11 $\Omega$<br>11 $\Omega$ to 33 $\Omega$<br>33 $\Omega$ to 110 $\Omega$<br>110 $\Omega$ to 330 $\Omega$<br>330 $\Omega$ to 1.1 k $\Omega$<br>1.1 k $\Omega$ to 3.3 k $\Omega$<br>3.3 k $\Omega$ to 11 k $\Omega$<br>11 k $\Omega$ to 33 k $\Omega$<br>33 k $\Omega$ to 110 k $\Omega$<br>110 k $\Omega$ to 330 k $\Omega$<br>330 k $\Omega$ to 1.1 M $\Omega$<br>1.1 M $\Omega$ to 3.3 M $\Omega$<br>3.3 M $\Omega$ to 11 M $\Omega$<br>11 M $\Omega$ to 33 M $\Omega$<br>33 M $\Omega$ to 110 M $\Omega$<br>110 M $\Omega$ to 330 M $\Omega$<br>330 M $\Omega$ to 1100 M $\Omega$ | 47 $\mu\Omega/\Omega$ + 1.2 m $\Omega$<br>35 $\mu\Omega/\Omega$ + 1.7 m $\Omega$<br>33 $\mu\Omega/\Omega$ + 1.6 m $\Omega$<br>32 $\mu\Omega/\Omega$ + 2.3 m $\Omega$<br>13 $\mu\Omega/\Omega$ + 54 m $\Omega$<br>11 $\mu\Omega/\Omega$ + 0.55 $\Omega$<br>32 $\mu\Omega/\Omega$ + 28 m $\Omega$<br>29 $\mu\Omega/\Omega$ + 0.41 $\Omega$<br>32 $\mu\Omega/\Omega$ + 0.3 $\Omega$<br>37 $\mu\Omega/\Omega$ + 2.4 $\Omega$<br>36 $\mu\Omega/\Omega$ + 3.7 $\Omega$<br>69 $\mu\Omega/\Omega$ + 35 $\Omega$<br>0.15 m $\Omega/\Omega$ + 61 $\Omega$<br>0.29 m $\Omega/\Omega$ + 2.8 k $\Omega$<br>0.59 m $\Omega/\Omega$ + 4.6 k $\Omega$<br>3.5 m $\Omega/\Omega$ + 0.11 M $\Omega$<br>17 m $\Omega/\Omega$ + 5.7 M $\Omega$ |                                                    |                                      |
| (b) Resistance                                      | 0.100 $\Omega$ to 0.110 $\Omega$<br>0.110 $\Omega$ to 0.200 $\Omega$<br>0.100 $\Omega$ to 1.100 $\Omega$<br>1.100 $\Omega$ to 10.100 $\Omega$<br>10.100 $\Omega$ to 100.100 $\Omega$<br>100.100 $\Omega$ to 1000.100 $\Omega$                                                                                                                                                                                                                                                                                                                                                                     | 0.12 m $\Omega/\Omega$ + 2.3 m $\Omega$<br>0.12 m $\Omega/\Omega$ + 2.3 m $\Omega$<br>0.12 m $\Omega/\Omega$ + 2.3 m $\Omega$<br>0.12 m $\Omega/\Omega$ + 2.3 m $\Omega$<br>0.12 m $\Omega/\Omega$ + 2.3 m $\Omega$<br>0.12 m $\Omega/\Omega$ + 2.3 m $\Omega$                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                    | Generate using<br>Yokogawa<br>279301 |

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## SCOPE OF CALIBRATION: ELECTRICAL

| Instrument Calibrated/<br>Measurement Parameter            | Range                                                                                                                                                                                                                                                                                                                                                                                                                  | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )*                                                                                                                                                                                                                                                                                                                            | Remarks                                            |
|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
| 1. Measuring Instruments<br>(continued)<br>(c) Capacitance | 220 pF to 400 pF<br>0.4 nF to 1.1 nF<br>1.1 nF to 3.3 nF<br>3.3 nF to 11 nF<br>11 nF to 33 nF<br>33 nF to 110 nF<br>110 nF to 330 nF<br>0.33 $\mu$ F to 1.1 $\mu$ F<br>1.1 $\mu$ F to 3.3 $\mu$ F<br>3.3 $\mu$ F to 11 $\mu$ F<br>11 $\mu$ F to 33 $\mu$ F<br>33 $\mu$ F to 110 $\mu$ F<br>110 $\mu$ F to 330 $\mu$ F<br>0.33 mF to 1.1 mF<br>1.1 mF to 3.3 mF<br>3.3 mF to 11 mF<br>11 mF to 33 mF<br>33 mF to 110 mF | 5.7 $\mu$ F/F + 12 pF<br>5.5 mF/F + 13 pF<br>5.8 mF/F + 12 pF<br>2.9 mF/F + 12 pF<br>3.4 mF/F + 6.8 pF<br>2.9 mF/F + 20 pF<br>2.9 mF/F + 58 pF<br>2.9 mF/F + 1.2 nF<br>2.9 mF/F + 3.5 nF<br>2.9 mF/F + 12 nF<br>4.5 mF/F + 38 nF<br>5.2 mF/F + 0.13 $\mu$ F<br>5.1 mF/F + 0.35 $\mu$ F<br>5.2 mF/F + 1.2 $\mu$ F<br>5.2 mF/F + 3.4 $\mu$ F<br>5.7 mF/F + 17 $\mu$ F<br>8.5 mF/F + 35 $\mu$ F<br>13 mF/F + 0.12 mF | Generate using<br>calibrator model<br>Fluke 5522 A |
| (d) AC Voltage<br>(See Matrix A)                           | <u>0 mV to 1020 V</u><br><u>See Matrix A</u>                                                                                                                                                                                                                                                                                                                                                                           | See Matrix A                                                                                                                                                                                                                                                                                                                                                                                                      |                                                    |
| (e) DC Current ( $\pm$ )                                   | 0 $\mu$ A to 330 $\mu$ A<br>0 mA to 3.3 mA<br>0 mA to 33 mA<br>0 mA to 330 mA<br>0 A to 1.1 A<br>1.1 A to 3 A<br>0 A to 11 A<br>11 A to 20.5 A                                                                                                                                                                                                                                                                         | 0.18 mA/A + 23 nA<br>0.12 mA/A + 58 nA<br>0.12 mA/A + 0.32 $\mu$ A<br>0.12 mA/A + 3.0 $\mu$ A<br>0.23 mA/A + 50 $\mu$ A<br>0.43 mA/A + 57 $\mu$ A<br>0.55 mA/A + 0.91 mA<br>1.2 mA/A + 1.1 mA                                                                                                                                                                                                                     |                                                    |
| (f) AC Current<br>(See Matrix B)                           | See Matrix B                                                                                                                                                                                                                                                                                                                                                                                                           | See Matrix B                                                                                                                                                                                                                                                                                                                                                                                                      |                                                    |

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Matrix A

AC Voltage Measurement. Generate using calibrator model Fluke 5522 A

| Range                 | Frequency           |                      |                      |                       |                       |                       |                        |                        |                         |                          |
|-----------------------|---------------------|----------------------|----------------------|-----------------------|-----------------------|-----------------------|------------------------|------------------------|-------------------------|--------------------------|
|                       | 10 Hz<br>to<br>45Hz | 45 Hz<br>to<br>1 kHz | 1 kHz<br>to<br>5 kHz | 5 kHz<br>to<br>10 kHz | 45 Hz<br>to<br>10 kHz | 1 kHz<br>to<br>10 kHz | 10 kHz<br>to<br>20 kHz | 20 kHz<br>to<br>50 kHz | 50 kHz<br>to<br>100 kHz | 100 kHz<br>to<br>500 kHz |
| 1 mV<br>to<br>33 mV   | 1.9 +<br>0.11       | -                    | -                    | -                     | 0.41 +<br>0.11        | -                     | 0.7 +<br>0.11          | 1.9 +<br>0.11          | 4.4 +<br>0.099          | 9.2 +<br>0.12            |
| 33 mV<br>to<br>330 mV | 1.8 +<br>0.11       | -                    | -                    | -                     | 0.43 +<br>0.11        | -                     | 0.71 +<br>0.11         | 1.8 +<br>0.11          | 2.5 +<br>0.11           | 3.2 +<br>0.13            |
| 0.33 V<br>to<br>3.3 V | 1.8 +<br>0.24       | -                    | -                    | -                     | 0.44 +<br>0.24        | -                     | 0.72 +<br>0.24         | 1.8 +<br>0.25          | 2.5 +<br>0.20           | 3.5 +<br>0.69            |
| 3.3 V<br>to<br>33 V   | 1.8 +<br>3.2        | -                    | -                    | -                     | 0.43 +<br>2.5         | -                     | 1.1 +<br>0.98          | 2.3 +<br>2.5           | 5.8 +<br>2.7            | -                        |
| 33 V<br>to<br>330 V   | -                   | 1.2 +<br>12          | -                    | -                     | -                     | 0.61 +<br>14          | 6.8 + 12               | 9.1 + 13               | 12 + 26                 | -                        |
| 330 V<br>to<br>1020 V | -                   | 1.8 +<br>36          | 0.85 +<br>37         | 0.87 +<br>37          | -                     | -                     | -                      | -                      | -                       | -                        |

The expanded uncertainties given in this table are expressed in mV/V + mV, unless otherwise stated.

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Matrix B:

AC Current Measurement. Generate using calibrator model Fluke 5522 A

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| Range                     | Frequency      |                    |                |                   |                     |                   |                   |                    |                   |
|---------------------------|----------------|--------------------|----------------|-------------------|---------------------|-------------------|-------------------|--------------------|-------------------|
|                           | 10 Hz to 20 Hz | 10 Hz to 45 Hz     | 20 Hz to 45 Hz | 45 Hz to 100 Hz   | 45 Hz to 1 kHz      | 100 Hz to 1 kHz   | 1 kHz to 5 kHz    | 5 kHz to 10 kHz    | 10 kHz to 30kHz   |
| 29 $\mu$ A to 330 $\mu$ A | 2.6 + 0.56     | -                  | 1.8 + 0.57     | -                 | 1.2 + 0.57          | -                 | 6.6 + 0.59        | 15 + 0.6           | 23 + 0.72         |
| 0.33 mA to 3.3 mA         | 2.8 + 1.5      | -                  | 1.5 + 1.5      | -                 | 0.94 + 1.5          | -                 | 6.1 + 1.7         | 13 + 1.7           | 19 + 0.89         |
| 3.3 mA to 33 mA           | 2.7 + 6.4      | -                  | 1.2 + 6.1      | -                 | 0.95 + 6.3          | -                 | 3.6 + 6.1         | 8.5 + 6.5          | 13 + 2.5          |
| 33 mA to 330 mA           | 2.7 + 63       | -                  | 1.2 + 59       | -                 | 0.49 + 59           | -                 | 1.2 + 78          | 2.6 mA/A + 0.13 mA | 8.1 mA/A + 0.2 mA |
| 0.33 A to 1.1 A           | -              | 3.0 mA/A + 0.59 mA | -              | -                 | 0.98 mA/A + 0.58 mA | -                 | 14 mA/A + 1.2 mA  | 37 mA/A + 5.2 mA   | -                 |
| 1.1 A to 3 A              | -              | 3.1 mA/A + 0.53 mA | -              | -                 | 1.1 mA/A + 0.57 mA  | -                 | 14 mA/A + 1.2 mA  | 37 mA/A + 5.0 mA   | -                 |
| 3 A to 11 A               | -              | -                  | -              | 2.4 mA/A + 4.4 mA | -                   | 1.6 mA/A + 4.2 mA | 36 mA/A + 3.3 mA  | -                  | -                 |
| 11 A to 20.5 A            | -              | -                  | -              | -                 | -                   | 2.7 mA/A + 6.1 mA | 2.7 mA/A + 7.1 mA | -                  | -                 |

The expanded uncertainties given in this table are expressed in mA/A+  $\mu$ A, unless otherwise stated.



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## SCOPE OF CALIBRATION:

## ELECTRICAL

| Instrument Calibrated/<br>Measurement Parameter | Range                                                                        | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks                                                                |
|-------------------------------------------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| 1. Generating Instruments                       |                                                                              |                                                                                        |                                                                        |
| (a) DC Voltage                                  | $\pm 100$ mV Range<br>$\pm (100 \mu\text{V to } 120 \text{ mV})$             | $4.4 \mu\text{V/V} + 0.7 \mu\text{V}$                                                  | Measure using<br>8 ½ Digit<br>Multimeter<br>Keysight 3458A<br>Opt. 002 |
|                                                 | $\pm 1$ V Range<br>$\pm (0.1 \text{ V to } 1.2 \text{ V})$                   | $3.6 \mu\text{V/V} + 1.9 \mu\text{V}$                                                  |                                                                        |
|                                                 | $\pm 10$ V Range<br>$\pm (1 \text{ V to } 12 \text{ V})$                     | $4.7 \mu\text{V/V} + 2.6 \mu\text{V}$                                                  |                                                                        |
|                                                 | $\pm 100$ V Range<br>$\pm (10 \text{ V to } 120 \text{ V})$                  | $6.1 \mu\text{V/V} + 0.16 \text{ mV}$                                                  |                                                                        |
|                                                 | $\pm 1000$ V Range<br>$\pm (100 \text{ V to } 1050 \text{ V})$               | $6.1 \mu\text{V/V} + 1.5 \text{ mV}$                                                   |                                                                        |
| (b) DC Current                                  | $\pm 100$ nA Range,<br>$\pm (1 \text{ nA to } 120 \text{ nA})$               | $34 \mu\text{A/A} + 47 \text{ pA}$                                                     |                                                                        |
|                                                 | $\pm 1$ $\mu\text{A}$ Range<br>$\pm (0.1 \mu\text{A to } 1.2 \mu\text{A})$   | $24 \mu\text{A/A} + 47 \text{ pA}$                                                     |                                                                        |
|                                                 | $\pm 10$ $\mu\text{A}$ Range,<br>$\pm (1 \mu\text{A to } 12 \mu\text{A})$    | $25 \mu\text{A/A} + 0.12 \text{ nA}$                                                   |                                                                        |
|                                                 | $\pm 100$ $\mu\text{A}$ Range,<br>$\pm (10 \mu\text{A to } 120 \mu\text{A})$ | $19 \mu\text{A/A} + 2.1 \text{ nA}$                                                    |                                                                        |
|                                                 | $\pm 1$ mA Range,<br>$\pm (0.1 \text{ mA to } 1.2 \text{ mA})$               | $22 \mu\text{A/A} + 11 \text{ nA}$                                                     |                                                                        |
|                                                 | $\pm 10$ mA Range<br>$\pm (1 \text{ mA to } 12 \text{ mA})$                  | $22 \mu\text{A/A} + 0.11 \mu\text{A}$                                                  |                                                                        |
|                                                 | $\pm 100$ mA Range,<br>$\pm (10 \text{ mA to } 120 \text{ mA})$              | $41 \mu\text{A/A} + 1.2 \mu\text{A}$                                                   |                                                                        |
|                                                 | $\pm 1$ A Range,<br>$\pm (0.1 \text{ A to } 1.05 \text{ A})$                 | $0.12 \text{ mA/A} + 23 \mu\text{A}$                                                   |                                                                        |
|                                                 | $\pm 3$ A Range,<br>$\pm (1 \text{ A to } 3 \text{ A})$                      | $0.14 \text{ mA/A} + 69 \mu\text{A}$                                                   | Measure using<br>6 ½ Digit<br>Multimeter<br>HP 34401A                  |

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**SCOPE OF CALIBRATION: ELECTRICAL**

| Instrument Calibrated/<br>Measurement Parameter           | Range                              | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks                                                                |
|-----------------------------------------------------------|------------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| 1. Generating Instruments<br>(continued)                  |                                    |                                                                                        |                                                                        |
| (c) Resistance,<br>(Four-wire Ohms and<br>Two-wire Ohms.) | 0 $\Omega$ to 12 $\Omega$          | 3.3 $\mu\Omega/\Omega$ + 76 m $\Omega$                                                 | Measure using<br>8 ½ Digit<br>Multimeter<br>Keysight 3458A<br>Opt. 002 |
|                                                           | 10 $\Omega$ to 120 $\Omega$        | 0.32 $\mu\Omega/\Omega$ + 0.56 m $\Omega$                                              |                                                                        |
|                                                           | 0.1 k $\Omega$ to 1.2 k $\Omega$   | 0.78 $\mu\Omega/\Omega$ + 0.55 m $\Omega$                                              |                                                                        |
|                                                           | 1 k $\Omega$ to 12 k $\Omega$      | 0.79 $\mu\Omega/\Omega$ + 5.5 m $\Omega$                                               |                                                                        |
|                                                           | 10 k $\Omega$ to 120 k $\Omega$    | 8.4 $\mu\Omega/\Omega$ + 0.45 $\Omega$                                                 |                                                                        |
|                                                           | 0.1 M $\Omega$ to 1.2 M $\Omega$   | 1.2 $\mu\Omega/\Omega$ + 1.2 $\Omega$                                                  |                                                                        |
|                                                           | 1 M $\Omega$ to 12 M $\Omega$      | 5.1 $\mu\Omega/\Omega$ + 21 $\Omega$                                                   |                                                                        |
|                                                           | 10 M $\Omega$ to 120 M $\Omega$    | 0.54 m $\Omega/\Omega$ + 4.5 m $\Omega$                                                |                                                                        |
|                                                           | 0.1 G $\Omega$ to 1.2 G $\Omega$   | 57 m $\Omega/\Omega$ + 12 k $\Omega$                                                   |                                                                        |
| (d) AC Voltage                                            | 10 mV to 700V<br>(See Matrix C)    | (See Matrix C)                                                                         |                                                                        |
| (e) AC Current                                            | 5 $\mu$ A to 1 A<br>(See Matrix D) | (See Matrix D)                                                                         |                                                                        |

Matrix C:

AC Voltage Generation. Measure using 8 ½ Digit Multimeter Keysight 3458A Opt. 002

| Range  |                       | AC Band $\leq$ 2 MHz          |                               |                              |                               |                              |                             |                         |                         |
|--------|-----------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|------------------------------|-----------------------------|-------------------------|-------------------------|
|        |                       | 1 Hz<br>to<br>40 Hz           | 40 Hz to<br>1 kHz             | 1 kHz<br>to<br>20 kHz        | 20 kHz<br>to<br>50 kHz        | 50 kHz<br>to<br>100 kHz      | 100 kHz<br>to<br>300 kHz    | 300 kHz<br>to<br>1 MHz  | 1 MHz<br>to<br>2 MHz    |
| 10 mV  | 1 mV<br>to<br>12 mV   | 0.32<br>mV/V +<br>4.4 $\mu$ V | 0.18<br>mV/V +<br>3 $\mu$ V   | 0.27<br>mV/V +<br>3 $\mu$ V  | 1.1<br>mV/V +<br>2.6 $\mu$ V  | 5.7<br>mV/V +<br>2.5 $\mu$ V | 47 mV/V<br>+ 2.7 $\mu$ V    | -                       | -                       |
| 100 mV | 12 mV<br>to<br>120 mV | 62 $\mu$ V/V +<br>9.7 $\mu$ V | 53 $\mu$ V/V<br>+ 8.7 $\mu$ V | 0.11<br>mV/V +<br>11 $\mu$ V | 0.29<br>mV/V +<br>9.5 $\mu$ V | 0.72<br>mV/V +<br>28 $\mu$ V | 3.3<br>mV/V +<br>37 $\mu$ V | 12 mV/V<br>+ 39 $\mu$ V | 18 mV/V<br>+ 31 $\mu$ V |
| 1 V    | 0.12 V<br>to<br>1.2 V | 84 $\mu$ V/V +<br>51 $\mu$ V  | 83 $\mu$ V/V<br>+ 31 $\mu$ V  | 0.17<br>mV/V +<br>29 $\mu$ V | 0.35<br>mV/V +<br>30 $\mu$ V  | 0.93<br>mV/V +<br>28 $\mu$ V | 3.5<br>mV/V +<br>0.13 mV    | 12 mV/V<br>+ 0.13<br>mV | 18 mV/V<br>+ 0.18 mV    |
| 10 V   | 1.2 V<br>to<br>12 V   | 85 $\mu$ V/V +<br>0.51 mV     | 83 $\mu$ V/V<br>+ 0.31<br>mV  | 0.17<br>mV/V +<br>0.29 mV    | 0.35<br>mV/V +<br>0.28 mV     | 0.93<br>mV/V +<br>0.26 mV    | 3.5<br>mV/V +<br>1.3 mV     | 12 mV/V<br>+ 1.3<br>mV  | 18 mV/V<br>+ 1.7 mV     |

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**SCOPE OF CALIBRATION: ELECTRICAL**

Matrix C (continued)

AC Voltage Generation. Measure using 8 ½ Digit Multimeter Keysight 3458A Opt. 002

| Range  |                | AC Band $\leq 2$ MHz |                    |                    |                   |                   |                    |                  |                |
|--------|----------------|----------------------|--------------------|--------------------|-------------------|-------------------|--------------------|------------------|----------------|
|        |                | 1 Hz to 40 Hz        | 40 Hz to 1 kHz     | 1 kHz to 20 kHz    | 20 kHz to 50 kHz  | 50 kHz to 100 kHz | 100 kHz to 300 kHz | 300 kHz to 1 MHz | 1 MHz to 2 MHz |
| 100 V  | 12 V to 120 V  | 0.24 mV/V + 5.1 mV   | 0.23 mV/V + 2.9 mV | 0.23 mV/V + 2.9 mV | 0.4 mV/V + 3.1 mV | 1.4 mV/V + 2.6 mV | 4.7 mV/V + 12 mV   | 18 mV/V + 12 mV  | -              |
| 1000 V | 120 V to 700 V | 0.45 mV/V + 67 mV    | 0.44 mV/V + 48 mV  | 0.68 mV/V + 43 mV  | 1.4 mV/V + 35 mV  | 3.5 mV/V + 28 mV  | -                  | -                | -              |

AC Voltage Generation. Measure using 8 ½ Digit Multimeter Keysight 3458A Opt. 002

| Range  |                 | AC Band $> 2$ MHz      |                       |                       |                        |                    |
|--------|-----------------|------------------------|-----------------------|-----------------------|------------------------|--------------------|
|        |                 | 45 Hz to 100 kHz       | 100 kHz to 1 MHz      | 1 MHz to 4 MHz        | 4 MHz to 8 MHz         | 8 MHz to 10 MHz    |
| 10 mV  | 1 mV to 12 mV   | 1.1 mV/V + 7.5 $\mu$ V | 14 mV/V + 6.3 $\mu$ V | 81 mV/V + 8.3 $\mu$ V | 0.24 V/V + 9.4 $\mu$ V | -                  |
| 100 mV | 12 mV to 120 mV | 1.1 mV/V + 71 $\mu$ V  | 24 mV/V + 63 $\mu$ V  | 47 mV/V + 88 $\mu$ V  | 47 mV/V + 0.1 mV       | 0.18 V/V + 0.12 mV |
| 1 V    | 120 mV to 1.2 V | 1.1 mV/V + 0.7 mV      | 24 mV/V + 0.58 mV     | 47 mV/V + 0.83 mV     | 47 mV/V + 0.95 mV      | 0.18 V/V + 1.2 mV  |
| 10 V   | 1.2 V to 12 V   | 1.1 mV/V + 7 mV        | 24 mV/V + 5.8 mV      | 47 mV/V + 8.7 mV      | 47 mV/V + 9.5 mV       | 0.18 V/V + 12 mV   |
| 100 V  | 12 V to 120 V   | 1.4 mV/V + 2.6 mV      | -                     | -                     | -                      | -                  |
| 1000 V | 120 V to 700 V  | 3.5 mV/V + 0.12 V      | -                     | -                     | -                      | -                  |

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**SCOPE OF CALIBRATION: ELECTRICAL**

Matrix D:

AC Current Generation. Measure using 8 ½ Digit Multimeter Keysight 3458A Opt. 002

| Range       |                          | Frequency Band               |                              |                               |                               |
|-------------|--------------------------|------------------------------|------------------------------|-------------------------------|-------------------------------|
|             |                          | 10 Hz to 20 Hz               | 20 Hz to 45 Hz               | 45 Hz to 100 Hz               | 100 Hz to 5 kHz               |
| 100 $\mu$ A | 5 $\mu$ A to 120 $\mu$ A | 4.7 nA/A + 36 nA             | 1.8 nA/A + 36 nA             | 0.7 nA/A + 36 nA              | 0.7 nA/A + 36 nA              |
| 1 mA        | 0.05 mA to 1.2 mA        | 4.7 $\mu$ A/A + 0.24 $\mu$ A | 1.8 $\mu$ A/A + 0.24 $\mu$ A | 0.71 $\mu$ A/A + 0.24 $\mu$ A | 0.36 $\mu$ A/A + 0.23 $\mu$ A |
| 10 mA       | 0.5 mA to 12 mA          | 4.7 $\mu$ A/A + 2.4 $\mu$ A  | 1.8 $\mu$ A/A + 2.4 $\mu$ A  | 0.7 $\mu$ A/A + 2.4 $\mu$ A   | 0.36 $\mu$ A/A + 2.5 $\mu$ A  |
| 100 mA      | 5 mA to 120 mA           | 4.7 $\mu$ A/A + 24 $\mu$ A   | 1.8 $\mu$ A/A + 2.4 $\mu$ A  | 0.7 $\mu$ A/A + 24 $\mu$ A    | 0.36 $\mu$ A/A + 25 $\mu$ A   |
| 1 A         | 0.05 A to 1.05 A         | 4.7 mA/A + 0.25 mA           | 1.9 mA/A + 0.25 mA           | 0.92 mA/A + 0.25 mA           | 1.3 mA/A + 0.15 mA            |

| Range  |                   | Frequency Band                |                              |                             |
|--------|-------------------|-------------------------------|------------------------------|-----------------------------|
|        |                   | 5 kHz to 20 kHz               | 20 kHz to 50 kHz             | 50 kHz to 100 kHz           |
| 1 mA   | 0.05 mA to 1.2 mA | 0.71 $\mu$ A/A + 0.24 $\mu$ A | 4.7 $\mu$ A/A + 0.47 $\mu$ A | 6.4 $\mu$ A/A + 1.8 $\mu$ A |
| 10 mA  | 0.5 mA to 12 mA   | 0.7 $\mu$ A/A + 2.4 $\mu$ A   | 4.7 $\mu$ A/A + 4.7 $\mu$ A  | 6.4 $\mu$ A/A + 18 $\mu$ A  |
| 100 mA | 5 mA to 120 mA    | 0.7 $\mu$ A/A + 24 $\mu$ A    | 4.7 $\mu$ A/A + 47 $\mu$ A   | 6.4 $\mu$ A/A + 0.18 mA     |
| 1 A    | 0.05 A to 1.05 A  | 3.5 mA/A + 0.25 mA            | 12 mA/A + 0.47 mA            | -                           |

Matrix E:

AC Current Generation. Measure using 6 ½ Digit Multimeter HP 34401A

| Range |            | Frequency Band   |                   |                   |
|-------|------------|------------------|-------------------|-------------------|
|       |            | 3 Hz to 5 Hz     | 5 Hz to 10 Hz     | 10 Hz to 5 kHz    |
| 3 A   | 1 A to 3 A | 13 mA/A + 2.1 mA | 4.0 mA/A + 2.1 mA | 1.8 mA/A + 2.1 mA |

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## FIELD OF CALIBRATION: ELECTRICAL

| Instrument Calibrated/<br>Measurement Parameter      | Range                                                                     | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks                                     |
|------------------------------------------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------|---------------------------------------------|
| <b>Clamp Meter</b><br>DC Current via<br>Current Coil | 10 A to 16.5 A<br>16.5 A to 150 A<br>150 A to 1025 A                      | 2.8 mA/A + 4.2 mA<br>4.3 mA/A - 54 mA<br>2.9 mA/A + 37 mA                              | Generate using<br>Calibrator Fluke<br>5522A |
| AC Current via<br>Current Coil                       | (45 Hz to 65 Hz)<br>10 A to 16.5 A<br>16.5 A to 150 A<br>150 A to 1025 A  | 2.7 mA/A + 19 mA<br>3.1 mA/A + 43 mA<br>3.1 mA/A + 0.23 A                              |                                             |
|                                                      | (65 Hz to 440 Hz)<br>10 A to 16.5 A<br>16.5 A to 150 A<br>150 A to 1025 A | 8.8 mA/A + 9.6 mA<br>9.0 mA/A + 31 mA<br>8.9 mA/A + 0.17 A                             |                                             |
| <b>Power Meters</b><br>DC Power Energy               | 0.1 W to 1 kW<br>1 kW to 20 kW                                            | 0.25 mW/W + 0.18 mW<br>0.80 mW/W - 1.7 mW                                              | Generate using<br>Fluke 5522A               |
| AC Power Energy                                      | (45 Hz to 65 Hz, PF=1)<br>0.1 W to 1 W<br>1 W to 10 kW<br>10 kW to 20 kW  | 0.2 mW/W + 23 mW<br>1.2 mW/W + 7.2 mW<br>1.2 mW/W + 31 mW                              |                                             |

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## SCOPE OF CALIBRATION: ELECTRICAL

| Instrument Calibrated/<br>Measurement Parameter             | Range                                                  | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks                                                                   |
|-------------------------------------------------------------|--------------------------------------------------------|----------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| <b>Oscilloscope</b><br>Vertical Deflection<br>DC Signal     | 0 V to $\pm 6.6$ V<br>(50 $\Omega$ Load)               | 2.8 mV/V + 0.48 mV                                                                     | Generating<br>using calibrator<br>model Fluke<br>5500A SC600              |
|                                                             | 0 V to $\pm 130$ V<br>(1 M $\Omega$ Load)              | 0.56 mV/V + 0.48 mV                                                                    |                                                                           |
| Vertical Deflection<br>Square Wave Signal                   | $\pm 1$ mVp-p to<br>$\pm 6.6$ Vp-p (50 $\Omega$ Load)  | 2.8 mVp-p/Vp-p + 0.48 mVp-p                                                            |                                                                           |
|                                                             | $\pm 1$ mVp-p to $\pm 130$ Vp-p<br>(1 M $\Omega$ Load) | 1.2 mVp-p/Vp-p + 0.47 mVp-p                                                            |                                                                           |
| Horizontal Deflection Time<br>Markers<br>(50 $\Omega$ Load) | 2 ns/div to 20 ms/div<br>50 ms/div to 5 s/div          | 73 ps/s + 12 ns<br>5.5 ms/s + 0.39 ms                                                  |                                                                           |
| Risetime                                                    | 1 kHz to 10 MHz<br>10 mV to 2.5 V                      | 7.9 ns/s + 7.2 ps                                                                      | Generate using<br>Agilent E4431B<br>ESG-D Series<br>Signal<br>Generator   |
| Bandwidth Frequency                                         | 50 kHz to 600 MHz<br>(5 mV to 5.5 V)                   | 2 mHz/Hz + 1.4 MHz                                                                     |                                                                           |
|                                                             | 250 kHz – 2 GHz<br>(+7 to –120 dBm)                    | 2 nHz/Hz + 1.4 MHz                                                                     | Generating<br>using calibrator<br>model Fluke<br>5500A SC600              |
| Bandwidth Amplitude                                         | 5 mV to 5.5 V<br>(50 kHz to 600 MHz)                   | 0.41 mVp-p/Vp-p + 0.34 Vp-p                                                            |                                                                           |
|                                                             | +7 to –120 dBm<br>(250 kHz – 2 GHz)                    | 0.26 Vp-p                                                                              | Generating<br>using Agilent<br>E4431B ESG-D<br>Series Signal<br>Generator |

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**SCOPE OF CALIBRATION: ELECTRICAL**

| Instrument Calibrated/<br>Measurement Parameter | Range                                                | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks      |
|-------------------------------------------------|------------------------------------------------------|----------------------------------------------------------------------------------------|--------------|
| Insulation Testers                              | (1.0 k $\Omega$ to 10.0 k $\Omega$ )<br>@ 10.0 V     | 1.2 m $\Omega/\Omega$ + 0.14 $\Omega$                                                  | Tinsley 4720 |
|                                                 | (10.0 k $\Omega$ to 100.0 k $\Omega$ )<br>@ 50.0 V   | 1.2 m $\Omega/\Omega$ + 1.4 $\Omega$                                                   |              |
|                                                 | (0.1 M $\Omega$ to 1.0 M $\Omega$ )<br>@ 150.0 V     | 0.94 m $\Omega/\Omega$ + 0.49 k $\Omega$                                               |              |
|                                                 | (1.0 M $\Omega$ to 10.0 M $\Omega$ )<br>@ 300.0 V    | 1.2 m $\Omega/\Omega$ + 0.14 k $\Omega$                                                |              |
|                                                 | (10.0 M $\Omega$ to 100.0 M $\Omega$ )<br>@ 500.0 V  | 1.3 m $\Omega/\Omega$ + 0.38 k $\Omega$                                                |              |
|                                                 | (0.1 G $\Omega$ to 1.0 G $\Omega$ )<br>@ 1000.0 V    | 13 m $\Omega/\Omega$ - 0.20 M $\Omega$                                                 |              |
|                                                 | (1.0 G $\Omega$ to 10.0 G $\Omega$ )<br>@ 5000.0 V   | 1.5 m $\Omega/\Omega$ - 1.9 M $\Omega$                                                 |              |
|                                                 | (10.0 G $\Omega$ to 100.0 G $\Omega$ )<br>@ 5000.0V  | 29 m $\Omega/\Omega$ - 0.43 G $\Omega$                                                 |              |
|                                                 | (100.0 G $\Omega$ to 500.0 G $\Omega$ )<br>@ 5000.0V | 40 m $\Omega/\Omega$ - 0.36 G $\Omega$                                                 |              |

**Signatories:**

1. Rushaida Abdul Aziz
2. \*\*Mohamed Fikri Bin Mohd Nor

\*\*Non-resident signatory

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**SCOPE OF CALIBRATION: ELECTRICAL (RF)**

| Instrument Calibrated/<br>Measurement Parameter | Range                                                             | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks                                                                                            |
|-------------------------------------------------|-------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| 1. Measuring Instrument                         |                                                                   |                                                                                        |                                                                                                    |
| (a) Frequency                                   | 1 $\mu$ Hz to 20 MHz                                              | 2.3 $\mu$ Hz/Hz + 2.1 $\mu$ Hz                                                         | Generate using<br>Agilent 33220A<br>Function / Arbitrary<br>Waveform<br>Generator                  |
|                                                 | 250 kHz to 2 GHz                                                  | 2 $\mu$ Hz/Hz + 0.3 Hz                                                                 | Generate using<br>Agilent E44318<br>ESG-D Series<br>Signal Generator                               |
| (b) Time Base Input                             | 10 MHz                                                            | 1 $\mu$ Hz/Hz                                                                          | Generate using<br>Agilent E44318<br>ESG-D Series<br>Signal Generator<br>(Rear Time Base<br>Output) |
| (c) Amplitude                                   | 10 mVpp to 10 Vpp<br>(1 $\mu$ Hz to 20 MHz,<br>Into 50 $\Omega$ ) | 12 mVpp/Vpp + 1.1 mVpp                                                                 | Generate using<br>Agilent 33220A<br>Function/ Arbitrary<br>Waveform<br>Generator                   |
|                                                 | 20 mVpp to 20 Vpp<br>(1 $\mu$ Hz to 20 MHz,<br>Into open circuit) | 11 mVpp/Vpp + 9.5 mVpp                                                                 |                                                                                                    |
|                                                 | +7 to -120 dBm<br>(250 kHz to 2 GHz)                              | -0.02 dBm/dBm + 0.06<br>dBm                                                            | Generate using<br>Agilent E44318<br>ESG-D Series<br>Signal Generator                               |
| (d) Modulation                                  |                                                                   |                                                                                        |                                                                                                    |
| AM Depth Calibration factor                     | 33.33 % nominal                                                   | 0.06 %                                                                                 | Generate using<br>HP 8901A<br>(Calibration Output)                                                 |
| FM Deviation Calibration<br>factor              | 340 kHz peak nominal                                              | 0.08 kHz                                                                               |                                                                                                    |



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**SCOPE OF CALIBRATION: ELECTRICAL (RF)**

| Instrument Calibrated/<br>Measurement Parameter                   | Range                                                                               | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks                                                      |
|-------------------------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|--------------------------------------------------------------|
| 2. Generating Instruments                                         |                                                                                     |                                                                                        |                                                              |
| (a) Frequency or Period                                           | 0.01 Hz to 225 MHz<br>6 ns to 100 s                                                 | 5.8 $\mu$ Hz/Hz + 0.15 mHz<br>5.8 $\mu$ s/s - 69 ps                                    | Measure using<br>Fluke PM 6680B<br>Timer Counter<br>Analyzer |
|                                                                   | 150 kHz to 650 MHz                                                                  | 14 $\mu$ Hz/Hz + 36 $\mu$ Hz                                                           |                                                              |
|                                                                   | 650 MHz to 1300 MHz                                                                 | 14 $\mu$ Hz/Hz + 35 $\mu$ Hz                                                           |                                                              |
| (b) Amplitude/ Level                                              | 0.1 W to 1 W<br>(150 kHz to 60 MHz)                                                 | 0.35 nW/W + 2.2 mW                                                                     | Measure using<br>HP 8901A                                    |
|                                                                   | 0.01 W to 0.1 W<br>(150 kHz to 60 MHz)                                              | 35 pW/W + 2.2 mW                                                                       |                                                              |
|                                                                   | 1 mW to 10 mW<br>(150 kHz to 60 MHz)                                                | 3.3 pW/W + 2.2 mW                                                                      |                                                              |
|                                                                   | 0.1 W to 1 W<br>(650 MHz to 1300 MHz)                                               | 0.30 nW/W + 2.6 mW                                                                     |                                                              |
|                                                                   | 0.01 W to 0.1 W<br>(650 MHz to 1300 MHz)                                            | 30 pW/W + 2.6 mW                                                                       |                                                              |
|                                                                   | 1 mW to 10 mW<br>(650 MHz to 1300 MHz)                                              | 2.2 pW/W + 2.6 mW                                                                      |                                                              |
| (c) MODULATION<br>Related Signal:<br>Amplitude Modulation<br>(AM) |                                                                                     |                                                                                        |                                                              |
| AM Depth: 1 % to 99 %                                             | Carrier Frequency<br>150 kHz to 10 MHz<br>Modulation Frequency<br>50 Hz to 10 kHz   | 0.024 %/% + 0.011 %                                                                    |                                                              |
| AM Depth: 1 % to 99 %                                             | Carrier Frequency<br>150 kHz to 10 MHz<br>Modulation Frequency<br>20 Hz to 10 kHz   | 0.036 %/% + 0.011 %                                                                    |                                                              |
| AM Depth: 1 % to 99 %                                             | Carrier Frequency<br>10 MHz to 1300 MHz<br>Modulation Frequency<br>50 Hz to 50 kHz  | 0.024 %/% + 0.011 %                                                                    |                                                              |
| AM Depth: 1 % to 99 %                                             | Carrier Frequency<br>10 MHz to 1300 MHz<br>Modulation Frequency<br>20 Hz to 100 kHz | 0.036 %/% + 0.011 %                                                                    |                                                              |

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**SCOPE OF CALIBRATION: ELECTRICAL (RF)**

| Instrument Calibrated/<br>Measurement Parameter                              | Range                                                                               | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks                |
|------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|------------------------|
| 2. Generating Instruments                                                    |                                                                                     |                                                                                        |                        |
| <i>Frequency Modulation (FM)</i>                                             |                                                                                     |                                                                                        |                        |
| <i>FM Deviation:<br/><math>\leq 40</math> kHz peak</i>                       | Carrier Frequency<br>150 kHz to 10 MHz<br>Modulation Frequency<br>20 Hz to 10 kHz   | 0.024 kHz/kHz + 0.0049 kHz                                                             | Measure using HP 8901A |
| <i>FM Deviation:<br/><math>\leq 400</math> kHz peak</i>                      | Carrier Frequency<br>10 MHz to 1300 MHz<br>Modulation Frequency<br>50 Hz to 100 kHz | 0.012 kHz/kHz + 0.12 kHz                                                               |                        |
| <i>FM Deviation:<br/><math>\leq 40</math> kHz peak</i>                       | Carrier Frequency<br>10 MHz to 1300 MHz<br>Modulation Frequency<br>20 Hz to 200 kHz | 0.057 kHz/kHz + 0.021 kHz                                                              |                        |
| <i>Phase Modulation (<math>\Phi M</math>)</i>                                |                                                                                     |                                                                                        |                        |
| <i><math>\Phi M</math> Deviation:<br/><math>\leq 400</math> Radians peak</i> | Carrier Frequency<br>10 kHz to 1300 MHz<br>Modulation Frequency<br>200 Hz to 20 kHz | 0.034 Radians/Radians + 0.12 Radians                                                   |                        |
| <i><math>\Phi M</math> Deviation:<br/><math>\leq 40</math> Radians peak</i>  | Carrier Frequency<br>10 kHz to 1300 MHz<br>Modulation Frequency<br>200 Hz to 20 kHz | 0.034 Radians/Radians + 0.012 Radians                                                  |                        |
| <i><math>\Phi M</math> Deviation:<br/><math>\leq 4</math> Radians peak</i>   | Carrier Frequency<br>10 kHz to 1300 MHz<br>Modulation Frequency<br>200 Hz to 8 kHz  | 0.034 Radians/Radians + 0.0013 Radians                                                 |                        |

**Signatories:**

3. Rushaida Abdul Aziz
4. \*\*Mohamed Fikri Bin Mohd Nor

\*\*Non-resident signatory

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**CALIBRATION: TIME AND FREQUENCY**

| Instrument Calibrated/<br>Measurement Parameter | Range                                                                      | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )*   | Remarks                                                         |
|-------------------------------------------------|----------------------------------------------------------------------------|------------------------------------------------------------------------------------------|-----------------------------------------------------------------|
| 1. Measuring Instruments                        |                                                                            |                                                                                          |                                                                 |
| a) Time                                         | 1 s to 24 Hrs                                                              | 0.83 ps/s + 29 ms                                                                        | Agilent 33220A &<br>Fluke PM 6680B<br>Timer Counter<br>Analyzer |
| b) RPM (Non-Contact)                            | 60 rpm to 999.99 rpm<br>1000.0 rpm to 9999.9 rpm<br>10000 rpm to 99999 rpm | 17 $\mu$ rpm/rpm + 8.4 mrpm<br>17 $\mu$ rpm/rpm + 84 mrpm<br>17 $\mu$ rpm/rpm + 0.84 rpm | In-House method,<br>ESF/0303                                    |

**Signatories:**

5. Rushaida Abdul Aziz
6. \*\*Mohamed Fikri Bin Mohd Nor

\*\*Non-resident signatory

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**SCOPE OF CALIBRATION: PRESSURE**

| Instrument Calibrated/<br>Measurement Parameter           | Range                                     | Calibration and<br>Measurement Capability<br>Expressed as an<br>Uncertainty ( $\pm$ )* | Remarks                         |
|-----------------------------------------------------------|-------------------------------------------|----------------------------------------------------------------------------------------|---------------------------------|
| Pressure measuring<br>device<br>(Hydraulic of oil medium) | 10 psi to 500 psi<br>500 psi to 10000 psi | 0.021% of pressure<br>0.025% of pressure                                               | Hydraulic Dead<br>Weight Tester |
| Pressure Vacuum Gauge                                     | -12 psi to 0 psi                          | 0.01 psi                                                                               | Digital Pressure<br>Indicator   |

**Signatory:****1. Nor Azila Mat Jusoh**