

issued by

2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK



Optical Test & Calibration Limited

Issue No: 054 Issue date: 03 July 2024

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Calibration performed at the above address only

| Measured Quantity Instrument or Gauge | Range | Expanded Measurement Uncertainty ($k = 2$) | Remarks |
|---|--|--|--|
| FIBRE OPTIC CALIBRATION | | | |
| OPTICAL POWER METERS | | | Calibration by comparison to reference |
| Absolute responsivity of fibre optic power meters with FC/PC connectors | Wavelength and Power levels: 850 nm - 10 dBm, - 20 dBm and - 23 dBm 1310 nm - 10 dBm, - 20 dBm and - 23 dBm 1550 nm - 10 dBm, - 20 dBm and - 23 dBm | 0.070 dB (1.5 %) 0.070 dB (1.5 %) 0.070 dB (1.5 %) | Wavelengths quoted are ± 1 nm 850 nm, multimode fibre 1310 nm, 1550 nm single mode fibre |
| Linearity of response of fibre optic power meters with FC/PC connectors | 850 nm 0dBm to - 35 dBm - 35 dBm to - 65 dBm - 65 dBm to - 70 dBm 1310 nm + 10 dBm to + 5 dBm + 5 dBm to - 5 dBm - 5 dBm to - 70 dBm 1550 nm + 10 dBm to 0 dBm 0 dBm to - 70 dBm | 0.070 dB (1.6 %) 0.090 dB (2.0 %) 0.120 dB (2.6 %) 0.100 dB (2.2 %) 0.070 dB (1.5 %) 0.060 dB (1.3 %) 0.080 dB (1.9 %) 0.060 dB (1.3 %) | 850 nm, multimode fibre 1310 nm 1550 nm single mode fibre |
| OPTICAL ATTENUATORS | | | |
| Insertion loss | 850 nm 1310 nm 1550 nm | 0.050 dB (1.0 %) 0.060 dB (1.2 %) 0.050 dB (1.0 %) | Fitted with FC/PC connectors |
| Attenuation setting | 850 nm: 0 dB to 65 dB 1310 nm: 0 dB to 70 dB 1550 nm: 0 dB to 70 dB | 0.060 dB (1.3 %) 0.060 dB (1.3 %) 0.060 dB (1.3 %) | Excluding insertion loss |



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| FIBRE OPTIC CALIBRATION (cont'd) | | | |
| OPTICAL ATTENUATORS (cont'd) | | | |
| Repeatability of attenuation setting | <i>850 nm</i> 0 dB to 65 dB <i>1310 nm and 1550 nm</i> 0 dB to 70 dB | 0.030 dB (0.60 %) 0.040 dB (0.90 %) | |
| OPTICAL TIME DOMAIN REFLECTOMETERS (OTDRs) (Single mode fibre) | | | Calibration by comparison to reference |
| Loss scale deviation | <i>1310 nm (nominal)</i> <i>1550 nm (nominal)</i> <i>1625 nm (nominal)</i> | 0.025 dB/dB 0.050 dB/dB 0.050 dB/dB | Results reported with standard adjacent to and remote from the UUT (typically at 7 km and 20 km respectively) |
| Length scale: | | | Measured by comparison to single mode fibre physical standards. |
| Zero location offset | | 0.30 m | Wavelengths: 1310 nm, 1550 nm and 1625 nm. |
| Distance scale factor | 6.5 km | 0.80 m | |
| Distance scale deviation | 6.5 km | 0.12 m/km | |
| Locational readout error | | 0.12 m | Pulse duration 3 ns to 20 μ s Maximum nominal power 25 mW, minimum nominal power 1 mW |
| CW FIBRE OPTIC LIGHT SOURCES | | | Calibration using optical power meter |
| Output power | <i>600 nm to 1650 nm:</i> - 5 dBm to - 55 dBm except where the following wavelength conditions are met: <i>850 nm \pm 1 nm:</i> 0 dBm to - 55 dBm <i>1310 nm \pm 1 nm</i> + 10 dBm to - 55 dBm <i>1550 nm \pm 1 nm</i> + 10 dBm to - 55 dBm | 0.30 dB (7.0 %) 0.070 dB (1.5 %) 0.070 dB (1.5 %) 0.070 dB (1.5 %) | CW source with RMS spectral width of less than 100 nm |



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| FIBRE OPTIC CALIBRATION (cont'd) | | | Calibration by comparison to reference standards |
| CW FIBRE OPTIC LIGHT SOURCES (cont'd) | | | |
| Output power stability of fibre optic light sources | - 5 dBm to – 55 dBm | 0.0040 dB (0.10 %) | Wavelength range 600 nm to 1650 nm |
| Centre Wavelength | 600 nm to 1650 nm 0 nm to 0.99 nm RMS 1 nm to 4.99 nm RMS 5 nm to 9.99 nm RMS 10 nm to 14.99 nm RMS 15 nm to 19.99 nm RMS 20 nm to 24.99 nm RMS 25 nm to 49.99 nm RMS 50 nm to 74.99 nm RMS 75 nm to 100 nm RMS | 0.10 nm 0.20 nm 0.40 nm 0.40 nm 0.40 nm 0.50 nm 1.20 nm 2.00 nm 3.00 nm | CW source with RMS spectral width of less than 100 nm |
| Peak Wavelength | 600 nm to 1650 nm 0 nm to 0.99 nm RMS 1 nm to 4.99 nm RMS 5 nm to 9.99 nm RMS 10 nm to 14.99 nm RMS 15 nm to 19.99 nm RMS 20 nm to 24.99 nm RMS 25 nm to 49.99 nm RMS 50 nm to 74.99 nm RMS 75 nm to 100 nm RMS | 0.10 nm 0.11 nm 0.33 nm 0.38 nm 0.47 nm 0.61 nm 1.88 nm 3.78 nm 6.00 nm | |
| Spectral width | 600 nm to 1650 nm 0 nm to 0.99 nm RMS 1 nm to 4.99 nm RMS 5 nm to 9.99 nm RMS 10 nm to 14.99 nm RMS 15 nm to 19.99 nm RMS 20 nm to 24.99 nm RMS 25 nm to 49.99 nm RMS 50 nm to 74.99 nm RMS 75 nm to 100 nm RMS | 0.05 nm 0.05 nm 0.30 nm 0.30 nm 0.31 nm 0.31 nm 0.68 nm 0.94 nm 1.31 nm | |



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| FIBRE OPTIC CALIBRATION (cont'd) PULSED FIBRE OPTIC LIGHT SOURCES Centre wavelength Spectral width OPTICAL FIBRES Length (single mode fibre) | 1200 nm to 1650 nm < 0.1 nm 0.1 nm to 9.9 nm 10 nm to 50 nm 0.25 m to 1 m 1 m to 16 km | 1.0 nm 0.20 nm 0.50 nm 0.90 nm 0.0020 m ($0.07 + (3 \times 10^{-5} \times L)$) m Where L is the length of the Fibre Under Test in metres. | Calibration by comparison to reference standards Pulse duration 3 ns to 20 μ s Maximum nominal power 25 mW, minimum nominal power 1 mW Pulsed source with RMS spectral width of less than 25 nm Intercomparison with physical standard Time of flight technique Wavelengths: 1310 nm, 1550 nm and 1625 nm |
| ILLUMINANCE for a source colour temperature of 2856 K Colour temperature LUMINANCE (luminance meters) for a source colour temperature of 2856 K | 1 lux to 10 lux 10 lux to 20 lux 20 lux to 200 lux 200 lux to 1000 lux 1000 lux to 2000 lux 2000 lux to 10 000 lux 10 000 lux to 20 000 lux 2856 K 1 cdm^{-2} to 20 cdm^{-2} 20 cdm^{-2} to 20000 cdm^{-2} | 3.1 % 2.8 % 2.2 % 1.7 % 2.2 % 2.3 % 2.7 % 0.80 % 5.4 % 5.1 % | Calibration by comparison to reference standards |



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| ELECTRICAL CALIBRATION | | | Calibrations are performed as a comparison against a reference standard |
| DC VOLTAGE | | | |
| Generation | 0 V to 330 mV 330 mV to 3.3 V 3.3 V to 33 V 33 V to 330 V 330 V to 1 kV | 17 $\mu\text{V/V} + 1.8 \mu\text{V}$ 14 $\mu\text{V/V} + 3.0 \mu\text{V}$ 13 $\mu\text{V/V} + 26 \mu\text{V}$ 13 $\mu\text{V/V} + 210 \mu\text{V}$ 13 $\mu\text{V/V} + 2.1 \text{ mV}$ | These values can be generated for the calibration of measuring instruments |
| Measurement | 0 V to 120 mV 120 mV to 1.2 V 1.2 V to 12 V 12 V to 120 V 120 V to 1 kV | 8.0 $\mu\text{V/V} + 1.3 \mu\text{V}$ 4.0 $\mu\text{V/V} + 1.3 \mu\text{V}$ 5.0 $\mu\text{V/V} + 2.0 \mu\text{V}$ 7.0 $\mu\text{V/V} + 40 \mu\text{V}$ 8.0 $\mu\text{V/V} + 120 \mu\text{V}$ | Outputs of instruments within these values can be measured to the listed uncertainties |
| DC CURRENT | | | |
| Generation | 0 μA to 330 μA 0.33 mA to 3.3 mA 3.3 mA to 33 mA 33 mA to 330 mA 330 mA to 3 A 3 A to 11 A 11 A to 20 A | 90 $\mu\text{A/A} + 25 \text{ nA}$ 43 $\mu\text{A/A} + 70 \text{ nA}$ 51 $\mu\text{A/A} + 0.40 \mu\text{A}$ 56 $\mu\text{A/A} + 4.0 \mu\text{A}$ 190 $\mu\text{A/A} + 70 \mu\text{A}$ 240 $\mu\text{A/A} + 0.80 \text{ mA}$ 720 $\mu\text{A/A} + 3.0 \text{ mA}$ | These values can be generated for the calibration of measuring instruments |
| Measurement | 0 μA to 120 μA 120 μA to 1.2 mA 1.2 mA to 12 mA 12 mA to 120 mA 120 mA to 1 A | 23 $\mu\text{A/A} + 1.7 \text{ nA}$ 17 $\mu\text{A/A} + 7.0 \text{ nA}$ 13 $\mu\text{A/A} + 70 \text{ nA}$ 41 $\mu\text{A/A} + 800 \text{ nA}$ 87 $\mu\text{A/A} + 14 \mu\text{A}$ | Outputs of instruments within these values can be measured to the listed uncertainties |
| DC RESISTANCE | | | |
| Generation | | | These values can be generated for the calibration of measuring instruments |
| Other values | 0 Ω to 11 Ω 11 Ω to 110 Ω 110 Ω to 1.1 k Ω 1.1 k Ω to 11 k Ω 11 k Ω to 110 k Ω 110 k Ω to 1.1 M Ω 1.1 M Ω to 11 M Ω 11 M Ω to 100 M Ω | 77 $\mu\Omega/\Omega + 1.2 \text{ m}\Omega$ 110 $\mu\Omega/\Omega + 1.8 \text{ m}\Omega$ 31 $\mu\Omega/\Omega + 2.4 \text{ m}\Omega$ 29 $\mu\Omega/\Omega + 24 \text{ m}\Omega$ 39 $\mu\Omega/\Omega + 240 \text{ m}\Omega$ 33 $\mu\Omega/\Omega + 3.0 \Omega$ 130 $\mu\Omega/\Omega + 59 \Omega$ 540 $\mu\Omega/\Omega + 3.6 \text{ k}\Omega$ | |



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| ELECTRICAL CALIBRATION (cont'd) | | | |
| DC RESISTANCE (cont'd) | | | |
| Measurement | 0 m Ω to 1 m Ω 1 m Ω to 10 m Ω 10 m Ω to 100 m Ω 100 m Ω to 1 Ω 1 Ω to 12 Ω 12 Ω to 120 Ω 120 Ω to 1.2 k Ω 1.2 k Ω to 12 k Ω 12 k Ω to 120 k Ω 120 k Ω to 1.2 M Ω 1.2 M Ω to 12 M Ω 12 M Ω to 120 M Ω 120 M Ω to 1 G Ω | 180 $\mu\Omega/\Omega$ + 1.5 $\mu\Omega$ 180 $\mu\Omega/\Omega$ + 1.7 $\mu\Omega$ 200 $\mu\Omega/\Omega$ + 9.0 $\mu\Omega$ 62 $\mu\Omega/\Omega$ + 50 $\mu\Omega$ 9.0 $\mu\Omega/\Omega$ + 70 $\mu\Omega$ 5.0 $\mu\Omega/\Omega$ + 700 $\mu\Omega$ 4.0 $\mu\Omega/\Omega$ + 1.2 m Ω 4.0 $\mu\Omega/\Omega$ + 13 m Ω 8.0 $\mu\Omega/\Omega$ + 120 m Ω 13 $\mu\Omega/\Omega$ + 3.3 Ω 27 $\mu\Omega/\Omega$ + 130 Ω 110 $\mu\Omega/\Omega$ + 1.3 k Ω 600 $\mu\Omega/\Omega$ + 13 k Ω | Outputs of instruments within these values can be measured to the listed uncertainties |
| AC VOLTAGE | | | |
| Generation | 45 Hz to 20 kHz 33 mV to 330 mV 330 mV to 3.3 V 3.3 V to 33 V 33 V to 330 V 20 kHz to 100 kHz 33 mV to 330 mV 330 mV to 3.3 V 3.3 V to 33 V 45 Hz to 10 kHz 330 V to 1000 V 500 kHz 300 mV 3 V | 0.0090 % + 10 μ V 0.0060 % + 71 μ V 0.012 % + 0.72 mV 0.025 % + 7.2 mV 0.030 % + 40 μ V 0.041 % + 160 μ V 0.033 % + 2.0 mV 0.020 % + 12 mV 0.14 % + 14 mV 0.12 % | These values can be generated for the calibration of measuring instruments |
| Measurement | 45 Hz to 20 kHz 12 mV to 120 mV 20 Hz to 20 kHz 120 mV to 1.2 V 20 kHz to 100 kHz 12 mV to 120 mV 120 mV to 1.2 V 20 Hz to 100 kHz 1.2 V to 12 V 12 V to 120 V 50 Hz to 20 kHz 120 V to 750 V | 0.010 % + 3.0 μ V 0.010 % + 50 μ V 0.010 % + 3.0 μ V 0.011 % + 40 μ V 0.036 % + 500 μ V 0.014 % + 5.0 mV 0.048 % + 24 mV | Outputs of instruments within these values can be measured to the listed uncertainties |



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| ELECTRICAL CALIBRATION (cont'd) | | | |
| AC CURRENT | | | |
| Generation | <i>33 μA to 330 μA</i> 20 Hz to 45 Hz 45 Hz to 1 kHz 1 kHz to 5 kHz <i>330 μA to 3.3 mA</i> 20 Hz to 45 Hz 45 Hz to 1 kHz 1 kHz to 5 kHz <i>3.3 mA to 33 mA</i> 20 Hz to 45 Hz 45 Hz to 1 kHz 1 kHz to 5 kHz <i>33 mA to 330 mA</i> 20 Hz to 45 Hz 45 Hz to 1 kHz 1 kHz to 5 kHz <i>330 mA to 3 A</i> 20 Hz to 45 Hz 45 Hz to 1 kHz 1 kHz to 5 kHz <i>3 A to 11 A</i> 45 Hz 45 Hz to 1 kHz 1 kHz to 5 kHz <i>11 A to 20 A</i> 45 Hz 45 Hz to 1 kHz 1 kHz to 5 kHz | 0.14 % + 0.12 μ A 0.090 % + 0.12 μ A 0.15 % + 0.18 μ A 0.040 % + 0.18 μ A 0.031 % + 0.18 μ A 0.052 % + 0.24 μ A 0.030 % + 2.4 μ A 0.022 % + 2.4 μ A 0.030 % + 2.4 μ A 0.040 % + 24 μ A 0.038 % + 24 μ A 0.046 % + 60 μ A 0.050 % + 0.20 mA 0.037 % + 0.12 mA 0.17 % + 1.2 mA 0.054 % + 2.4 mA 0.070 % + 2.4 mA 1.2 % + 2.4 mA 0.070 % + 6.0 mA 0.10 % + 6.0 mA 2.6 % + 6.0 mA | These values can be generated for the calibration of measuring instruments |
| Measurement | <i>20 Hz to 1 kHz</i> 10 μ A to 120 μ A <i>20 Hz to 5 kHz</i> 120 μ A to 1.2 mA 1.2 mA to 12 mA 12 mA to 120 mA 120 mA to 1 A | 0.030 % + 35 nA 0.043 % + 0.24 μ A 0.055 % + 2.3 μ A 0.065 % + 23 μ A 0.20 % + 240 μ A | Outputs of instruments within these values can be measured to the listed uncertainties |



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| ELECTRICAL CALIBRATION (cont'd) | | | |
| CAPACITANCE | | | |
| Generation | 0.2 nF to 0.4 nF 0.4 nF to 1.0 nF 1.0 nF to 10 nF 10 nF to 100 nF 100 nF to 1.0 μ F 1.0 μ F to 10 μ F 10 μ F to 100 μ F 100 μ F to 1.0 mF | 2.0 % + 12 pF 0.60 % + 12 pF 0.20 % + 12 pF 0.11 % + 120 pF 0.10 % + 1.2 nF 0.15 % + 12 nF 0.30 % + 120 nF 0.20 % + 1.2 μ F | These values can be generated for the calibration of measuring instruments |
| FREQUENCY | | | |
| Generation | 0.5 Hz to 10 Hz 10 Hz to 100 Hz 100 Hz to 1 kHz 1 kHz to 100 kHz 100 kHz to 2 MHz | 18 μ Hz/Hz + 6.0 μ Hz 2.6 μ Hz/Hz + 6.0 μ Hz 1.6 μ Hz/Hz + 6.0 μ Hz 1.0 μ Hz/Hz + 6.0 μ Hz 1.0 μ Hz/Hz + 6.0 μ Hz | May also be expressed as 1/ f for periodic time of repetitive events |
| Measurement | 1 Hz to 40 Hz 40 Hz to 10 MHz | 37 μ Hz/Hz 34 μ Hz/Hz | |
| RADIOMETRY | | | |
| Responsivity of UV detectors at power levels 0.3 to 5 mWcm ⁻² | 365 nm | | Calibration by comparison to reference standards |
| Detectors up to 25 mm | | 10 % | |
| Responsivity of uv detectors at power levels 0.3 to 2 mWcm ⁻² | | | |
| Detectors 25 mm to 40 mm | | 10 % | |
| END | | | |



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Appendix - Calibration and Measurement Capabilities

Introduction

The definitive statement of the accreditation status of a calibration laboratory is the Accreditation Certificate and the associated Schedule of Accreditation. This Schedule of Accreditation is a critical document, as it defines the measurement capabilities, ranges and boundaries of the calibration activities for which the organisation holds accreditation.

Calibration and Measurement Capabilities (CMCs)

The capabilities provided by accredited calibration laboratories are described by the Calibration and Measurement Capability (CMC), which expresses the lowest measurement uncertainty that can be achieved during a calibration. If a particular device under calibration itself contributes significantly to the uncertainty (for example, if it has limited resolution or exhibits significant non-repeatability) then the uncertainty quoted on a calibration certificate will be increased to account for such factors.

The CMC is normally used to describe the uncertainty that appears in an accredited calibration laboratory's schedule of accreditation and is the uncertainty for which the laboratory has been accredited using the procedure that was the subject of assessment. The measurement uncertainty is calculated according to the procedures given in the GUM and is normally stated as an expanded uncertainty at a coverage probability of 95 %, which usually requires the use of a coverage factor of $k = 2$. An accredited laboratory is not permitted to quote an uncertainty that is smaller than the published measurement uncertainty in certificates issued under its accreditation.

Expression of CMCs - symbols and units

It should be noted that the percentage symbol (%) represents the number 0.01. In cases where the measurement uncertainty is stated as a percentage, this is to be interpreted as meaning percentage of the measurand. Thus, for example, a measurement uncertainty of 1.5 % means $1.5 \times 0.01 \times q$, where q is the quantity value.

The notation $Q[a, b]$ stands for the root-sum-square of the terms between brackets: $Q[a, b] = [a^2 + b^2]^{1/2}$