



PERRY JOHNSON LABORATORY ACCREDITATION, INC.

Certificate of Accreditation

Perry Johnson Laboratory Accreditation, Inc. has assessed the Laboratory of:

TOTAL Calibration Solutions, Inc.

7722 Metric Drive, Mentor, OH 44060

*(Hereinafter called the Organization) and hereby declares that Organization is accredited
in accordance with the recognized International Standard:*

**ISO/IEC 17025:2017
ANSI/NCSL Z540-1-1994**

This accreditation demonstrates technical competence for a defined scope and the
operation of a laboratory quality management system
(as outlined by the joint ISO-ILAC-IAF Communiqué dated April 2017):

***Dimensional, Electrical, Mechanical, Thermodynamic, Time and Frequency,
and Mass, Force and Weighing Device Calibration***
(As detailed in the supplement)

Accreditation claims for such testing and/or calibration services shall only be made from addresses referenced within this certificate. This Accreditation is granted subject to the system rules governing the Accreditation referred to above, and the Organization hereby covenants with the Accreditation body's duty to observe and comply with the said rules.

For PJLA:

Tracy Szerszen
President

Initial Accreditation Date:

September 4, 2017

Issue Date:

July 22, 2020

Expiration Date:

October 31, 2022

Accreditation No.:

97175

Certificate No.:

L20-434-1

Perry Johnson Laboratory
Accreditation, Inc. (PJLA)
755 W. Big Beaver, Suite 1325
Troy, Michigan 48084

*The validity of this certificate is maintained through ongoing assessments based
on a continuous accreditation cycle. The validity of this certificate should be
confirmed through the PJLA website: www.pjllabs.com*



Certificate of Accreditation: Supplement

TOTAL Calibration Solutions, Inc.

7722 Metric Drive, Mentor, OH, 44060
Contact Name: Mark Hanson Phone: 440-299-4811

Accreditation is granted to the facility to perform the following calibrations:

Dimensional

| MEASURED INSTRUMENT, QUANTITY OR GAUGE | RANGE OR NOMINAL DEVICE SIZE AS APPROPRIATE | CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (\pm) | CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED |
|---|---|---|---|
| Calipers ^{FO} | Up to 40 in | (12L + 150) μ in | Gage Blocks / Surface Plate |
| Micrometers ^{FO} | Up to 6 in | (9.2L + 21) μ in | |
| | 6 in to 20 in | (16L + 177) μ in | |
| Indicators, Dial, Test ^{FO} | Up to 4 in | (30L - 5.5) μ in | |
| Height Gages ^{FO} | Up to 48 in | (10L + 205) μ in | Gage Line Glass Standard |
| Optical Comparators X and Y Axis Linearity ^{FO} | Up to 12 in | 200 μ in | |
| Optical Comparators Magnification ^{FO} | 10 x, 20 x, 31.25 x, 50 x, 62.5 x, 100 x | 200 μ in | |
| Optical Comparators Angle ^{FO} | 0°, 5°, 10°, 15°, 20°, 25°, 30°, 45°, 90° | 0.10° | Gage Line Glass Standard and Angle Blocks |

Electrical

| MEASURED INSTRUMENT, QUANTITY OR GAUGE | RANGE OR NOMINAL DEVICE SIZE AS APPROPRIATE | CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (\pm) | CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED |
|--|---|---|---|
| Equipment to Measure DC Voltage ^{FO} | Up to 100 mV | 1.8 μ V | HP 3458A Opt 002 |
| | 100 mV to 1 V | 7 μ V | |
| | 1 V to 10 V | 72 μ V | |
| | 10 V to 100 V | 1.2 mV | |
| | 100 V to 1 kV | 30 mV | |
| | 1 kV to 4 kV | 2.2 V | Vitretek 4700 |
| | 4 kV to 10 kV | 3.9 V | |
| | 10 kV to 30 kV | 0.027 kV | Vitretek 4700, Vitretek HVL-100 |
| | 30 kV to 50 kV | 0.045 kV | |
| Equipment to Output DC Voltage ^{FO} | 50 kV to 100 kV | 0.15 kV | Fluke 5522A |
| | Up to 330 mV | 8.2 μ V | |
| | 330 mV to 3.3 V | 41 μ V | |
| | 3.3 V to 33 V | 0.45 mV | |
| | 33 V to 330 V | 6.5 mV | |
| Equipment to Measure DC Current ^{FO} | 330 V to 1 kV | 23 mV | HP 3458A Opt 002 |
| | Up to 100 μ A | 7.4 nA | |
| | 100 μ A to 1 mA | 84 nA | |
| | 1 mA to 10 mA | 0.71 μ A | |
| | 10 mA to 100 mA | 10 μ A | |
| | 100 mA to 1 A | 0.16 mA | |



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|--|---|---|---|
| Equipment to Measure DC Current ^{FO} | 1 A to 3 A | 11 mA | HP 3458A Opt 002, HP 34330A Shunt |
| | 3 A to 11 A | 40 mA | |
| | 11 A to 20.5 A | 73 mA | |
| Equipment to Source DC Current ^{FO} | Up to 330 µA | 0.11 µA | Fluke 5522A |
| | 330 µA to 3.3 mA | 0.56 µA | |
| | 3.3 mA to 33 mA | 9.1 µA | |
| | 33 mA to 330 mA | 87 µA | |
| | 330 mA to 1.1 A | 0.29 mA | |
| | 1.1 A to 3 A | 1.3 mA | |
| | 3 A to 11 A | 7.1 mA | |
| | 11 A to 20.5 A | 25 mA | |
| Equipment to Measure AC Voltage At the listed frequencies ^{FO} | | | HP 3458A Opt 002 |
| Up to 1 kHz | Up to 10 mV | 4.7 µV | |
| 1 kHz to 20 kHz | Up to 10 mV | 9 µV | |
| 20 kHz to 100 kHz | Up to 10 mV | 90 µV | |
| 100 kHz to 300 kHz | Up to 10 mV | 0.72 mV | |
| Equipment to Measure AC Voltage At the listed frequencies ^{FO} | | | |
| Up to 1 kHz | 10 mV to 100 mV | 12 µV | |
| 1 kHz to 20 kHz | 10 mV to 100 mV | 20 µV | |
| 20 kHz to 100 kHz | 10 mV to 100 mV | 0.1 mV | |
| 100 kHz to 300 kHz | 10 mV to 100 mV | 0.39 mV | |
| Equipment to Measure AC Voltage At the listed frequencies ^{FO} | | | |
| Up to 1 kHz | 100 mV to 1 V | 0.12 mV | |
| 1 kHz to 20 kHz | 100 mV to 1 V | 0.2 mV | |
| 20 kHz to 50 kHz | 100 mV to 1 V | 0.39 mV | |
| 50 kHz to 100 kHz | 100 mV to 1 V | 0.97 mV | |
| 100 kHz to 300 kHz | 100 mV to 1 V | 3.6 mV | |
| 300 kHz to 500 kHz | 100 mV to 1 V | 12 mV | |
| Equipment to Measure AC Voltage At the listed frequencies ^{FO} | | | |
| Up to 10 Hz | 1 V to 10 V | 3.8 mV | |
| 10 Hz to 20 Hz | 1 V to 10 V | 1.4 mV | |



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|--|---|---|---|------------------------------------|
| Equipment to Measure AC Voltage At the listed frequencies ^{FO} | | | HP 3458A Opt 002 | |
| 20 Hz to 40 Hz | 1 V to 10 V | 1.2 mV | | |
| 40 Hz to 1 kHz | 1 V to 10 V | 1.2 mV | | |
| 1 kHz to 10 kHz | 1 V to 10 V | 2 mV | | |
| Equipment to Measure AC Voltage At the listed frequencies ^{FO} | | | | |
| 10 kHz to 20 kHz | 1 V to 10 V | 2 mV | | |
| 20 kHz to 50 kHz | 1 V to 10 V | 3.9 mV | | |
| 50 kHz to 100 kHz | 1 V to 10 V | 9.6 mV | | |
| Equipment to Measure AC Voltage At the listed frequencies ^{FO} | | | | |
| Up to 1 kHz | 10 V to 100 V | 27 mV | Vitretek 4700 | |
| 1 kHz to 20 kHz | 10 V to 100 V | 28 mV | | |
| 20 kHz to 50 kHz | 10 V to 100 V | 45 mV | | |
| 50 kHz to 100 kHz | 10 V to 100 V | 0.15 V | | |
| Equipment to Measure AC Voltage At the listed frequencies ^{FO} | | | | |
| Up to 20 kHz | 100 V to 1 kV | 0.36 V | | |
| Equipment to Measure AC Voltage At the listed frequencies ^{FO} | | | | Vitretek 4700, Vitretek HVL-100 |
| 60 Hz | 1 kV to 10 kV | 0.021 kV | | |
| 60 Hz | 10 kV to 75 kV | 0.18 kV | | |
| Equipment to Source AC Voltage At the listed frequencies ^{FO} | | | Fluke 5522A | |
| 10 Hz to 45 Hz | Up to 33 mV | 35 µV | | |
| 45 Hz to 10 kHz | Up to 33 mV | 12 µV | | |
| 10 kHz to 20 kHz | Up to 33 mV | 14 µV | | |
| 20 kHz to 50 kHz | Up to 33 mV | 42 µV | | |
| 50 kHz to 100 kHz | Up to 33 mV | 0.14 mV | | |
| 100 kHz to 500 kHz | Up to 33 mV | 0.34 mV | | |
| Equipment to Source AC Voltage At the listed frequencies ^{FO} | | | | |
| 10 Hz to 45 Hz | 33 mV to 330 mV | 0.12 mV | | |
| 45 Hz to 10 kHz | 33 mV to 330 mV | 60 µV | | |
| 10 kHz to 20 kHz | 33 mV to 330 mV | 65 µV | | |



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|---|---|---|---|
| Equipment to Source AC Voltage At the listed frequencies ^{FO} | | | Fluke 5522A |
| 20 kHz to 50 kHz | 33 mV to 330 mV | 0.13 mV | |
| 50 kHz to 100 kHz | 33 mV to 330 mV | 0.32 mV | |
| Equipment to Source AC Voltage At the listed frequencies ^{FO} | | | |
| 10 Hz to 45 Hz | 330 mV to 3.3 V | 11 mV | |
| 45 Hz to 10 kHz | 330 mV to 3.3 V | 0.59 mV | |
| 10 kHz to 20 kHz | 330 mV to 3.3 V | 0.73 mV | |
| 20 kHz to 50 kHz | 330 mV to 3.3 V | 1.1 mV | |
| 50 kHz to 100 kHz | 330 mV to 3.3 V | 2.9 mV | |
| 100 kHz to 500 kHz | 330 mV to 3.3 V | 9.1 mV | |
| Equipment to Source AC Voltage At the listed frequencies ^{FO} | | | |
| 10 Hz to 45 Hz | 3.3 V to 33 V | 11 mV | |
| 45 Hz to 10 kHz | 3.3 V to 33 V | 5.9 mV | |
| 10 kHz to 20 kHz | 3.3 V to 33 V | 9.1 mV | |
| 20 kHz to 50 kHz | 3.3 V to 33 V | 13 mV | |
| 50 kHz to 100 kHz | 3.3 V to 33 V | 33 mV | |
| Equipment to Source AC Voltage At the listed frequencies ^{FO} | | | |
| 45 Hz to 1 kHz | 33 V to 330 V | 69 mV | |
| 1 kHz to 10 kHz | 33 V to 330 V | 79 mV | |
| 10 kHz to 20 kHz | 33 V to 330 V | 94 mV | |
| 20 kHz to 50 kHz | 33 V to 330 V | 0.12 V | |
| 50 kHz to 100 kHz | 33 V to 330 V | 0.53 V | |
| Equipment to Source AC Voltage At the listed frequencies ^{FO} | | | |
| 45 Hz to 1 kHz | 330 V to 1.02 kV | 0.34 V | |
| 1 kHz to 5 kHz | 330 V to 1.02 kV | 0.28 V | |
| 5 kHz to 10 kHz | 330 V to 1.02 kV | 0.33 V | |
| Equipment to Source AC Current At the Listed frequencies ^{FO} | | | Fluke 5522A |
| 10 Hz to 20 Hz | 29 µA to 330 µA | 0.82 µA | |
| 20 Hz to 45 Hz | 29 µA to 330 µA | 0.64 µA | |
| 45 Hz to 1 kHz | 29 µA to 330 µA | 0.55 µA | |



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| Equipment to Source AC Current At the listed frequencies ^{FO} | | | Fluke 5522A |
| 1 kHz to 5 kHz | 29 µA to 330 µA | 1.2 µA | |
| 5 kHz to 10 kHz | 29 µA to 330 µA | 3 µA | |
| 10 kHz to 30 kHz | 29 µA to 330 µA | 6 µA | |
| Equipment to Source AC Current At the listed frequencies ^{FO} | | | |
| 10 Hz to 20 Hz | 330 µA to 3.3 mA | 7.6 µA | |
| 20 Hz to 45 Hz | 330 µA to 3.3 mA | 4.8 µA | |
| 45 Hz to 1 kHz | 330 µA to 3.3 mA | 3.9 µA | |
| 1 kHz to 5 kHz | 330 µA to 3.3 mA | 8 µA | |
| 5 kHz to 10 kHz | 330 µA to 3.3 mA | 19 µA | |
| 10 kHz to 30 kHz | 330 µA to 3.3 mA | 38 µA | |
| Equipment to Source AC Current At the listed frequencies ^{FO} | | | |
| 10 Hz to 20 Hz | 3.3 mA to 33 mA | 66 µA | |
| 20 Hz to 45 Hz | 3.3 mA to 33 mA | 34 µA | |
| 45 Hz to 1 kHz | 3.3 mA to 33 mA | 17 µA | |
| 1 kHz to 5 kHz | 3.3 mA to 33 mA | 32 µA | |
| 5 kHz to 10 kHz | 3.3 mA to 33 mA | 74 µA | |
| 10 kHz to 30 kHz | 3.3 mA to 33 mA | 0.14 mA | |
| Equipment to Source AC Current At the listed frequencies ^{FO} | | | |
| 10 Hz to 20 Hz | 33 mA to 330 mA | 0.65 mA | |
| 20 Hz to 45 Hz | 33 mA to 330 mA | 0.34 mA | |
| 45 Hz to 1 kHz | 33 mA to 330 mA | 0.16 mA | |
| 1 kHz to 5 kHz | 33 mA to 330 mA | 0.41 mA | |
| 5 kHz to 10 kHz | 33 mA to 330 mA | 0.81 mA | |
| 10 kHz to 30 kHz | 33 mA to 330 mA | 1.6 mA | |
| Equipment to Source AC Current At the listed frequencies ^{FO} | | | |
| 10 Hz to 45 Hz | 330 mA to 1.1 A | 2.2 mA | |
| 45 Hz to 1 kHz | 330 mA to 1.1 A | 0.71 mA | |
| 1 kHz to 5 kHz | 330 mA to 1.1 A | 8.1 mA | |
| 5 kHz to 10 kHz | 330 mA to 1.1 A | 35 mA | |



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|--|---|---|---|
| Equipment to Source AC Current At the listed frequencies ^{FO} | | | Fluke 5522A |
| 10 Hz to 45 Hz | 1.1 A to 3 A | 6.2 mA | |
| 45 Hz to 1 kHz | 1.1 A to 3 A | 2.2 mA | |
| 1 kHz to 5 kHz | 1.1 A to 3 A | 21 mA | |
| Equipment to Source AC Current At the listed frequencies ^{FO} | | | |
| 45 Hz to 100 Hz | 3 A to 11 A | 10 mA | |
| 100 Hz to 1 kHz | 3 A to 11 A | 15 mA | |
| 1 kHz to 5 kHz | 3 A to 11 A | 0.38 A | |
| Equipment to Source AC Current At the listed frequencies ^{FO} | | | |
| 45 Hz to 100 Hz | 11 A to 20.5 A | 34 mA | HP 3458A Opt 002 |
| 100 Hz to 1 kHz | 11 A to 20.5 A | 41 mA | |
| 1 kHz to 5 kHz | 11 A to 20.5 A | 0.7 A | |
| Equipment to Measure AC Current At the listed frequencies ^{FO} | | | |
| 10 Hz to 5 kHz | Up to 100 µA | 0.11 µA | |
| Equipment to Measure AC Current At the listed frequencies ^{FO} | | | |
| 10 Hz to 5 kHz | 100 µA to 1 mA | 0.6 µA | |
| Equipment to Measure AC Current At the listed frequencies ^{FO} | | | |
| 10 Hz to 5 kHz | 1 mA to 10 mA | 6.1 µA | |
| Equipment to Measure AC Current At the listed frequencies ^{FO} | | | |
| 10 Hz to 5 kHz | 10 mA to 100 mA | 61 µA | |
| Equipment to Measure AC Current At the listed frequencies ^{FO} | | | |
| 10 Hz to 5 kHz | 100 mA to 1.1 A | 1.4 mA | |
| Equipment to Measure AC Current At the listed frequencies ^{FO} | | | |
| 10 Hz to 40 Hz | 1.1 A to 3.3 A | 13 mA | |
| 40 Hz to 1 kHz | 1.1 A to 3.3 A | 12 mA | |
| 1 kHz to 5 kHz | 1.1 A to 3.3 A | 0.2 A | |



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|--|---|---|---|
| Equipment to Measure AC Current At the listed frequencies ^{FO} | | | HP 3458A Opt 002 with HP 34330A Shunt |
| 45 Hz to 1 kHz | 3 A to 11 A | 43 mA | |
| 45 Hz to 1 kHz | 3 A to 11 A | 43 mA | |
| Equipment to Measure AC Current At the listed frequencies ^{FO} | | | |
| 45 Hz to 1 kHz | 11 A to 20.5 A | 12 mA | |
| 1 kHz to 5 kHz | 11 A to 20.5 A | 0.2 A | |
| Equipment to Source Inductance ^{FO} | 100 μ H to 1 mH | 17 μ H | GR 1491D Decade Box , RLC GenRad 1689 |
| | 1 mH to 10 mH | 0.14 mH | |
| | 10 mH to 100 mH | 0.69 mH | |
| | 100 mH to 1 H | 6.9 mH | |
| | 1 H to 10 H | 69 mH | |
| Equipment to Measure Inductance ^{FO} | 100 μ H to 1 mH | 0.24 μ H | RLC GenRad 1689 |
| | 1 to 10 mH | 2.4 μ H | |
| | 10 mH to 100 mH | 24 μ H | |
| | 100 mH to 1 H | 0.24 mH | |
| | 1 H to 10 H | 2.3 mH | |
| Equipment to Measure Capacitance ^{FO} | Up to 1 nF | 0.64 pF | RLC GenRad 1689 |
| | 1 nF to 10 nF | 2.4 pF | |
| | 10 nF to 100 nF | 26 pF | |
| | 100 nF to 1 μ F | 0.41 nF | |
| | 1 μ F to 1.111 μ F | 0.44 nF | |
| Equipment to Source Capacitance At the listed frequencies ^{FO} | | | 1423A Decade Box |
| 20 Hz to 1 kHz | 100 pF to 1 nF | 0.67 pF | |
| 20 Hz to 1 kHz | 1 nF to 10 nF | 42 pF | |
| 20 Hz to 1 kHz | 10 nF to 100 nF | 74 pF | |
| 20 Hz to 1 kHz | 100 nF to 1 μ F | 0.62 nF | |
| 10 Hz to 10 kHz | 220 pF to 400 pF | 15 pF | Fluke 5522A |
| 10 Hz to 10 kHz | 0.4 nF to 1.1 nF | 18 pF | |
| 10 Hz to 3 kHz | 1.1 nF to 3.3 nF | 23 pF | |
| 10 Hz to 1 kHz | 3.3 nF to 11 nF | 44 pF | |
| 10 Hz to 1 kHz | 11 nF to 33 nF | 0.17 nF | |
| 10 Hz to 1 kHz | 33 nF to 110 nF | 0.44 nF | |



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| Equipment to Source Capacitance At the listed frequencies ^{FO} | | | Fluke 5522A |
| 10 Hz to 1 kHz | 110 nF to 330 nF | 0.92 nF | |
| 10 Hz to 600 Hz | 330 nF to 1.1 μ F | 4.1 nF | |
| 10 Hz to 300 Hz | 1.1 μ F to 3.3 μ F | 12 nF | |
| 10 Hz to 150 Hz | 3.3 μ F to 11 μ F | 44 nF | |
| 10 Hz to 120 Hz | 11 μ F to 33 μ F | 0.18 μ F | |
| 10 Hz to 80 Hz | 33 μ F to 110 μ F | 0.7 μ F | |
| 0 Hz to 50 Hz | 110 μ F to 330 μ F | 2 μ F | |
| Equipment to Source Capacitance At the listed frequencies ^{FO} | | | Fluke 5522A |
| 0 Hz to 20 Hz | 330 μ F to 1.1 mF | 12 μ F | |
| 0 Hz to 6 Hz | 1.1 mF to 3.3 mF | 20 μ F | |
| 0 Hz to 2 Hz | 3.3 mF to 11 mF | 89 μ F | |
| 0 Hz to 0.6 Hz | 11 mF to 33 mF | 0.31 mF | |
| 0 Hz to 0.2 Hz | 33 mF to 110 mF | 1.4 mF | |
| Equipment to Source DC Resistance ^{FO} | Up to 10 Ω | 1.6 m Ω | ESI RS925A Resistance Decade Box |
| | 10 Ω to 100 Ω | 3.1 m Ω | |
| | 100 Ω to 1 k Ω | 27 m Ω | |
| | 1 k Ω to 10 k Ω | 0.26 Ω | |
| | 10 k Ω to 100 k Ω | 2.6 Ω | |
| | 100 k Ω to 1.1 M Ω | 29 Ω | |
| | Up to 10 Ω | 1.6 m Ω | Fluke 5522A |
| | 1.1 M Ω to 3.3 M Ω | 0.29 k Ω | |
| | 3.3 M Ω to 11 M Ω | 0.35 k Ω | |
| | 11 M Ω to 33 M Ω | 12 k Ω | |
| | 33 M Ω to 110 M Ω | 66 k Ω | |
| | 110 M Ω to 330 M Ω | 1.2 M Ω | |
| | 330 M Ω to 1.1 G Ω | 18 M Ω | |
| | Up to 10 Ω | 0.31 m Ω | HP 3458A Opt 002 |
| | 10 Ω to 100 Ω | 2.7 m Ω | |
| | 100 Ω to 1 k Ω | 18 m Ω | |
| | 1 k Ω to 10 k Ω | 0.18 Ω | |
| | 10 k Ω to 100 k Ω | 1.8 Ω | |



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| Equipment to Measure DC Resistance ^{FO} | 100 kΩ to 1 MΩ | 25 Ω | HP 3458A Opt 002 |
| | 1 MΩ to 10 MΩ | 0.78 kΩ | |
| | 10 MΩ to 100 MΩ | 68 kΩ | |
| Oscilloscopes Amplitude – DC ^{FO} | | | Fluke 5522A / SC1100 |
| 50 Ω | -6.6 V to 6.6 V | 20 mV | |
| 1 MΩ | -130 V to 130 V | 15 mV | |
| Amplitude - Square Wave | | | |
| 50 Ω | 1 mV to 6.6 V (p-p) | 13 mV | |
| 1 MΩ | 1 mV to 130 V (p-p) | 18 mV | |
| Frequency | 10 Hz to 10 kHz | 29 Hz | |
| Time Markers into 50 Ω Load | 1 ns to 20 ms | 8.2 μs | |
| | 50 ms to 5 s | 29 ms | |
| Leveled Sine Wave (5 mV to 5.5 V) p-p | 50 kHz reference | 0.13 V | |
| | 50 kHz to 100 MHz | 0.1 V | |
| | 100 MHz to 300 MHz | 0.14 V | |
| | 300 MHz to 600 MHz | 0.26 V | |
| Leveled Sine Wave (5 mV to 3.5 V) p-p | 600 MHz to 1.1 GHz | 0.2 V | |
| Edge Characteristics into 50 Ω Load Rise Time Amplitude Frequency | Up to 300 ps | +0/-120 ps | |
| | 4.5 mV to 2.75 V | 63 mV | |
| | 1 kHz to 10 MHz | 29 Hz | |
| Wave Generator Square, Sine, Triangle Amplitude Into 50 Ω Load Into 1 MΩ Load Frequency | 1.8 mV to 55 V p-p | 88 mV | |
| | 1.8 mV to 55 V p-p | 2 V | |
| | 10 Hz to 100 kHz | 0.29 Hz | |
| Pulse – Generate 50 Ω Load Period Width | 22 ms to 200 ns 45.5 Hz to 5 MHz | 6.1 ns | |
| | 4 ns to 500 ns | 1.2 ns | |
| Input Resistance Measurement | 40 Ω to 60 Ω | 56 mΩ | |
| | 500 kΩ to 1.5MΩ | 2.5 kΩ | |
| Oscilloscope Capacitance Measurement | 5 pF to 50 pF | 1.3 pF | |



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|---|---|---|---|
| Electrical Simulation of Thermocouple Indicators Type B ^{FO} | 600 °C to 800 °C | 0.53 °C | Fluke 5522A |
| | 800 °C to 1 000 °C | 0.42 °C | |
| | 1 000 °C to 1 550 °C | 0.37 °C | |
| | 1 550 °C to 1 820 °C | 0.4 °C | |
| Electrical Simulation of Thermocouple Indicators Type C ^{FO} | 0 °C to 150 °C | 0.35 °C | |
| | 150 °C to 650 °C | 0.31 °C | |
| | 650 °C to 1 000 °C | 0.38 °C | |
| | 1 000 °C to 1 800 °C | 0.59 °C | |
| | 1 800 °C to 2 316 °C | 0.98 °C | |
| Electrical Simulation of Thermocouple Indicators Type E ^{FO} | -250 °C to -100 °C | 0.58 °C | |
| | -100 °C to -25 °C | 0.19 °C | |
| | -25 °C to 350 °C | 0.17 °C | |
| | 350 °C to 650 °C | 0.19 °C | |
| | 650 °C to 1 000 °C | 0.25 °C | |
| Electrical Simulation of Thermocouple Indicators Type J ^{FO} | -210 °C to -100 °C | 0.33 °C | |
| | -100 °C to -30 °C | 0.2 °C | |
| | -30 °C to 150 °C | 0.17 °C | |
| | 150 °C to 760 °C | 0.21 °C | |
| | 760 °C to 1 200 °C | 0.27 °C | |
| Electrical Simulation of Thermocouple Indicators Type K ^{FO} | -200 °C to -100 °C | 0.39 °C | |
| | -100 °C to -25 °C | 0.22 °C | |
| | -25 °C to 120 °C | 0.19 °C | |
| | 120 °C to 1 000 °C | 0.31 °C | |
| | 1 000 °C to 1 372 °C | 0.48 °C | |
| Electrical Simulation of Thermocouple Indicators Type L ^{FO} | -200 °C to -100 °C | 0.44 °C | |
| | -100 °C to 800 °C | 0.32 °C | |
| | 800 °C to 900 °C | 0.22 °C | |
| Electrical Simulation of Thermocouple Indicators Type N ^{FO} | -200 °C to -100 °C | 0.47 °C | |
| | -100 °C to -25 °C | 0.26 °C | |
| | -25 °C to 120 °C | 0.23 °C | |
| | 120 °C to 410 °C | 0.22 °C | |
| | 410 °C to 1 300 °C | 0.33 °C | |



Certificate of Accreditation: Supplement

TOTAL Calibration Solutions, Inc.

7722 Metric Drive, Mentor, OH, 44060
Contact Name: Mark Hanson Phone: 440-229-4811

Accreditation is granted to the facility to perform the following calibrations:

Electrical

| MEASURED INSTRUMENT, QUANTITY OR GAUGE | RANGE OR NOMINAL DEVICE SIZE AS APPROPRIATE | CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (\pm) | CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED |
|--|---|---|---|
| Electrical Simulation of Thermocouple Indicators Type R ^{FO} | 0 °C to 250 °C | 0.67 °C | Fluke 5522A |
| | 250 °C to 400 °C | 0.42 °C | |
| | 400 °C to 1 000 °C | 0.4 °C | |
| | 1 000 °C to 1 767 °C | 0.48 °C | |
| Electrical Simulation of Thermocouple Indicators Type S ^{FO} | 0 °C to 250 °C | 0.56 °C | |
| | 250 °C to 1 000 °C | 0.43 °C | |
| | 1 000 °C to 1 400 °C | 0.44 °C | |
| | 1 400 °C to 1 767 °C | 0.54 °C | |
| Electrical Simulation of Thermocouple Indicators Type T ^{FO} | -250 °C to -150 °C | 0.74 °C | |
| | -150 °C to 0 °C | 0.3 °C | |
| | 0 °C to 120 °C | 0.19 °C | |
| | 120 °C to 400 °C | 0.17 °C | |
| Electrical Simulation of Thermocouple Indicators Type U ^{FO} | -200 °C to 0 °C | 0.66 °C | |
| | 0 °C to 600 °C | 0.33 °C | |
| Electrical Simulation of RTD Indicators Pt 385, 100 Ω ^{FO} | -200 °C to -80 °C | 0.06 °C | |
| | -80 °C to 0 °C | 0.06 °C | |
| | 0 °C to 100 °C | 0.09 °C | |
| | 100 °C to 300 °C | 0.11 °C | |
| | 300 °C to 400 °C | 0.12 °C | |
| | 400 °C to 630 °C | 0.14 °C | |
| | 630 °C to 800 °C | 0.27 °C | |
| Electrical Simulation of RTD Indicators Pt 385, 200 Ω ^{FO} | -200 °C to -80 °C | 0.05 °C | |
| | -80 °C to 0 °C | 0.05 °C | |
| | 0 °C to 100 °C | 0.05 °C | |
| | 100 °C to 260 °C | 0.06 °C | |
| | 260 °C to 300 °C | 0.15 °C | |
| | 300 °C to 400 °C | 0.18 °C | |
| | 400 °C to 600 °C | 0.18 °C | |
| | 600 °C to 630 °C | 0.19 °C | |



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|---|---|---|---|
| Electrical Simulation of RTD Indicators Pt 385, 500 Ω ^{FO} | -200 °C to -80 °C | 0.05 °C | Fluke 5522A |
| | -80 °C to 0 °C | 0.06 °C | |
| | 0 °C to 100 °C | 0.06 °C | |
| | 100 °C to 260 °C | 0.07 °C | |
| | 260 °C to 300 °C | 0.09 °C | |
| | 300 °C to 400 °C | 0.09 °C | |
| | 400 °C to 600 °C | 0.11 °C | |
| | 600 °C to 630 °C | 0.13 °C | |
| Electrical Simulation of RTD Indicators Pt 385, 1000 Ω ^{FO} | -200 °C to -80 °C | 0.04 °C | Fluke 5522A |
| | -80 °C to 0 °C | 0.04 °C | |
| | 0 °C to 100 °C | 0.08 °C | |
| | 100 °C to 260 °C | 0.06 °C | |
| | 260 °C to 300 °C | 0.07 °C | |
| | 300 °C to 400 °C | 0.08 °C | |
| | 400 °C to 600 °C | 0.08 °C | |
| | 600 °C to 630 °C | 0.27 °C | |
| Phase Angle - Source (0 to 360)° ^{FO} | 65 Hz to 500 Hz | 0.29 ° | Fluke 5522A |
| Equipment to measure RF Power at listed Frequencies ^{FO} | | | |
| 150 kHz to 1.3 GHz | -20 dBm to 30 dBm | 0.21 dBm | HP 8902A / HP 11722A |
| 1.3 GHz to 18 GHz | -70 dBm to 10 dBm | 0.23 dBm | AGILENT E4418B / E4412A |
| | 10 dBm to 20 dBm | 0.16 dBm | |
| Tuned RF Absolute Power – Measure 2.5 MHz to 1.3 GHz ^{FO} | -20 dBm to 10 dBm | 0.15 dBm | HP 8902A / HP 11722A |
| | -40 dBm to -20 dBm | 0.16 dBm | |
| | -50 dBm to -40 dBm | 0.11 dBm | |
| | -60 dBm to -50 dBm | 0.07 dBm | |
| | -70 dBm to -60 dBm | 0.11 dBm | |
| | -80 dBm to -70 dBm | 0.11 dBm | |
| | -90 dBm to -80 dBm | 0.07 dBm | |
| | -100 dBm to -90 dBm | 0.07 dBm | |
| | -110 dBm to -100 dBm | 0.16 dBm | |
| | -120 dBm to -110 dBm | 0.13 dBm | |
| | -127 dBm to -120 dBm | 0.13 dBm | |



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Electrical

| MEASURED INSTRUMENT, QUANTITY OR GAUGE | RANGE OR NOMINAL DEVICE SIZE AS APPROPRIATE | CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (\pm) | CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED |
|--|---|---|---|
| Equipment to Measure Amplitude Modulation at the listed Frequencies and Rates ^{FO} | | | |
| Frequency: 150 kHz to 10 MHz Rate: 50 Hz to 10 kHz | 5 % to 99 % | 2.3 % | HP 8902A |
| Frequency: 150 kHz to 10 MHz Rate: 20 Hz to 10 kHz | to 99 % | 3.5 % | |
| Frequency: 10 MHz to 1.3 GHz Rate: 50 Hz to 50 kHz | 5 % to 99 % | 1.2 % | |
| Frequency: 10 MHz to 1.3 GHz Rate: 20 Hz to 100 kHz | to 99 % | 3.5 % | |
| Equipment to Measure Frequency Modulation at the listed Frequencies and Rates ^{FO} | | | |
| Frequency: 250 kHz to 10 MHz Rate: 20 Hz to 10 kHz ≤ 40 kHz peak | 0 Hz to 4 kHz 4 kHz to 40 kHz | 0.12 kHz 1.1 kHz | HP 8902A |
| Frequency: 10 MHz to 1.3 GHz Rate: 50 Hz to 100 kHz ≤ 400 kHz peak | 0 Hz to 4 kHz 4 kHz to 40 kHz 40 kHz to 400 kHz | 0.18 kHz 0.64 kHz 4.8 kHz | |
| Frequency: 10 MHz to 1.3 GHz Rate: 20 Hz to 200 kHz ≤ 400 kHz peak | 0 Hz to 4 kHz 4 kHz to 40 kHz 40 kHz to 400 kHz | 0.3 kHz 2.5 kHz 24 kHz | |
| Equipment to Measure Phase Modulation at the listed Frequencies ^{FO} | | | |
| 150 kHz to 10 MHz | 0 to 2 π rad | 0.32 rad | |
| 10 MHz to 1.3 GHz | 0 to 2 π rad | 0.56 rad | |



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Thermodynamic

| MEASURED INSTRUMENT, QUANTITY OR GAUGE | RANGE OR NOMINAL DEVICE SIZE AS APPROPRIATE | CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (\pm) | CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED |
|---|---|---|---|
| Humidity ^{FO} | Up to 10 % RH | 1.4 % | Vaisala HMT 333 / HMP75 Thunder Scientific 2500 |
| | 10 % RH to 95 % RH | 0.71 % | |
| Temperature ^{FO} | -196 °C | 0.021 °C | Liquid Nitrogen Temperature Bath Fluke 5628 PRT HP 3458A Opt 002 |
| | -95 °C to -20 °C | 0.021 °C | |
| | -20 °C to 150 °C | 0.017 °C | |
| | 150 °C to 660 °C | 0.062 °C | |

Time and Frequency

| MEASURED INSTRUMENT, QUANTITY OR GAUGE | RANGE OR NOMINAL DEVICE SIZE AS APPROPRIATE | CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (\pm) | CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED |
|---|--|---|---|
| Frequency – Source ^{FO} | 1 MHz to 3 GHz | 29 parts in 10^{10} | HP E4422B Signal Generator locked to FS725 Rubidium Frequency Standard |
| Frequency – Measure ^{FO} | 0.1 GHz to 3 GHz | 28 parts in 10^{10} | HP 53132A |
| Rotational Speed | 0 rpm to 8 000 rpm | 3.8 rpm | Reference Tachometer |

Mechanical

| MEASURED INSTRUMENT, QUANTITY OR GAUGE | RANGE OR NOMINAL DEVICE SIZE AS APPROPRIATE | CALIBRATION AND MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (\pm) | CALIBRATION EQUIPMENT AND REFERENCE STANDARDS USED |
|---|--|---|--|
| Pressure Gages & Transducers ^{FO} | -1 psig to 1 psig | 0.000 24 psig | Fluke 7250LP |
| | 1 psig to 5 psig | 0.03 % of reading | Fluke PM600-A1.4M with Fluke 6270A Pressure Controller |
| | 5 psig to 200 psig | 0.015 % of reading | |
| | 200 psig to 20 000 psig | 0.012 % of reading | Fluke 93116 Deadweight Tester |
| Vacuum ^{FO} | Up to 15 psia | 0.03 % of reading | Druck DPI 145 |
| Mass Flow ^{FO} | 0.5 sccm to 50 sccm | 0.31 % of reading | Mesa Labs ML-800-3 |
| | 50 sccm to 5 000 sccm | 0.16 % of reading | Mesa Labs ML-800-24 |
| | 5 slpm to 100 slpm | 0.18 % of reading | Mesa Labs ML-800-75 |
| | 100 slpm to 5 000 slpm | 0.28 % of reading | Fluke molbox+ mass flow terminal and Fluke 5E2-S, 2E3-S, or 1E4-S molbloc. |
| Liquid Flow ^{FO} | 1 gpm to 60 gpm | 0.45 % of reading | Cox Liquid Flow Standard |



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Mechanical

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|---|--|---|---|
| Equipment to Source Torque ^{FO} | 2.5 in-lb to 500 in-lb | 0.1 % of reading | Torque Arms, F Class Weights |
| | 41.6 ft-lb to 800 ft-lb | | |
| Torque Tools ^{FO} | 0.12 in-lb to 1.25 in-lb | 0.6 % of reading | Mountz BMX20Z |
| | 1.25 in-lb to 10 in-lb | 0.59 % of reading | Mountz TL10i |
| | 10 in-lb to 500 in-lb | 0.3 % of reading | Norbar 50621 |
| | 42 ft-lb to 75 ft-lb | 0.31 % of reading | Norbar 50593 |
| | 75 ft-lb to 750 ft-lb | 0.31 % of reading | Norbar 50597 |

Mass, Force, and Weighing Devices

| | | | |
|--|-----------------------------|------------|-----------------|
| Force - Compression & Tension ^{FO} | Up to 500 lbf | 0.1 lbf | Class F Weights |
| | 500 lbf to 1 000 lbf | 0.63 lbf | Load Cells |
| | 1 000 lbf to 2 500 lbf | 2.1 lbf | |
| | 2 500 lbf to 5 000 lbf | 2.7 lbf | |
| | 5 000 lbf to 7 500 lbf | 5.3 lbf | |
| | 7 500 lbf to 10 000 lbf | 6.3 lbf | |
| | 10 000 lbf to 25 000 lbf | 22 lbf | |
| | 25 000 lbf to 50 000 lbf | 31 lbf | |
| Laboratory and Precision Balances ^{FO} | Up to 20 g (0.001 mg) | 14 μ g | Class 1 Weights |
| | 20 g to 40 g (0.01 mg) | 30 μ g | |
| | 40 g to 60 g (0.01 mg) | 39 μ g | |
| | 60 g to 80 g (0.01 mg) | 45 μ g | |
| | 80 g to 100 g (0.01 mg) | 71 μ g | |
| | 100 g to 200 g (0.01 mg) | 77 μ g | |
| | 200 g to 500 g (0.1 mg) | 0.89 mg | |
| | 500 kg to 1 kg (1 mg) | 2.6 mg | |
| | 1 kg to 2 kg (1 mg) | 2.8 mg | |
| | 2 kg to 4 kg (1 mg) | 4.3 mg | |
| | | | |



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|--|--|---|---|
| Laboratory and Precision Balances ^{FO} | 4 kg to 5 kg Res.= (1 mg) | 14 mg | Class 1 Weights |
| | 5 kg to 10 kg Res.= (1 mg) | 24 mg | |
| | 10 kg to 15 kg Res.= (1 mg) | 99 mg | |
| | 15 kg to 20 kg Res.= (0.1 g) | 0.11 g | |
| | 4 kg to 5 kg Res.= (1 mg) | 14 mg | |
| Scale ^{FO} | Up to 20 lb Res.= (0.001 lb) | 0.001 1 lb | Class F Weights |
| | 20 lb to 50 lb Res.= (0.01 lb) | 0.007 4 lb | |
| | 50 lb to 100 lb Res.= (0.01 lb) | 0.009 6 lb | |
| | 100 lb to 600 lb Res.= (0.1 lb) | 0.077 lb | |
| | 600 lb to 1 000 lb Res.= (0.1 lb) | 0.12 lb | |
| | 1 000 lb to 2 000 lb Res.= (0.1 lb) | 0.17 lb | |
| | 2 000 lb to 3 000 lb Res.= (0.5 lb) | 0.37 lb | |
| | 3 000 lb to 4 000 lb Res.= (0.5 lb) | 0.48 lb | |
| Pipettes ^{FO} | 0.5 μ L to 2 μ L | 0.076 μ L | Micro-Balance |
| | 2 μ L to 10 μ L | 0.078 μ L | |
| | 10 μ L to 20 μ L | 0.08 μ L | |
| | 20 μ L to 100 μ L | 0.094 μ L | |
| | 100 μ L to 200 μ L | 0.16 μ L | |
| | 200 μ L to 500 μ L | 0.4 μ L | |
| | 500 μ L to 1 000 μ L | 0.51 μ L | |
| | 1 000 μ L to 5 100 μ L | 2.5 μ L | |



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|---|--|---|--|
| Mass ^{FO} | Up to 2 g | 0.002 mg | Class 0 Weights with: Micro Balance Semi-Micro Balance Analytical Balance Medium Precision Balance Heavy Precision Balance |
| | 2 g to 20 g | 0.009 mg | |
| | 20 g to 200 g | 0.046 mg | |
| | 200 g to 1 000 g | 0.17 mg | |
| | 1 000 g to 3 000 g | 1.1 mg | |
| | 3 000 g to 5 000 g | 3.4 mg | |
| | 5 000 g to 10 000 g | 6.5 mg | |
| | 10 kg to 30 kg | 0.15 g | |
| | 30 kg to 60 kg | 0.74 g | |

1. The CMC (Calibration and Measurement Capability) stated for calibrations included on this scope of accreditation represents the smallest measurement uncertainty attainable by the laboratory when performing a more or less routine calibration of a nearly ideal device under nearly ideal conditions. It is typically expressed at a confidence level of 95 % using a coverage factor k (usually equal to 2). The actual measurement uncertainty associated with a specific calibration performed by the laboratory will typically be larger than the CMC for the same calibration since capability and performance of the device being calibrated and the conditions related to the calibration may reasonably be expected to deviate from ideal to some degree.
2. The laboratories range of calibration capability for all disciplines for which they are accredited is the interval from the smallest calibrated standard to the largest calibrated standard used in performing the calibration. The low end of this range must be an attainable value for which the laboratory has or has access to the standard referenced. Verification of an indicated value of zero in the absence of a standard is common practice in the procedure for many calibrations but by its definition it does not constitute calibration of zero capacity.
3. The presence of a superscript FO means that the laboratory performs calibration of the indicated parameter both at its fixed location and onsite at customer locations. Example: Outside Micrometer^{FO} would mean that the laboratory performs this calibration at its fixed location and onsite at customer locations.
4. The term L represents length in inches or millimeters as appropriate to the uncertainty statement.