INyMET
INDISPENSABLES PARA LA CALIDAD

Número de Certificado: **IMF-0970-2022**
Certificate number

Fecha de Calibración: **2022-12-23**
Calibration date

Laboratorio de Metrología en Tiempo y Frecuencia

Certificado de Calibración

Calibration Certificate

DATOS DEL USUARIO
User data

Nombre: Name	SPECTRALAB INSTRUMENTACIÓN, S.A. DE C.V.
Domicilio: Address	Chimalpopoca No. 76, El Arenal 2da. Sección 15680, Venustiano Carranza, Ciudad de México.

DATOS DEL INSTRUMENTO
Instrument data

Instrumento: Instrument	TACÓMETRO DIGITAL		
Marca: Brand name	SMART SENSOR	**Modelo:** Model	AR925
Número de serie: Serial number	SIN SERIE	**Identificación:** ID number	R5

CONFORMIDAD
Conformity

Criterio de Evaluación: Evaluation criterion	*NO APLICA*	**Declaración:** Statement	*VER OBSERVACIONES*
Próxima calibración: Next calibration	2023-12-23	POR SOLICITUD DEL USUARIO	

CONDICIONES DE CALIBRACIÓN
Calibration conditions

Fecha de recepción: Reception date	2022-12-21	**HRE No.:** Reception number	59958
Temperatura ambiente Environmental temperature	(20 ± 0,5) °C	**Humedad Relativa:** Relative humidity	(26 ± 10) %HR
Fecha de Emisión: Issue date	2023-01-03		
Procedimiento(s) utilizado(s): Procedure(s) used	IM-PRO-TF02		
Lugar de la calibración: Calibration site	Laboratorio de Metrología en Tiempo y Frecuencia		

Calibró:
Calibrated by

Malcolm Díaz Yee
Metrólogo del Laboratorio

ISO/IEC 17025:2017

IAS ACCREDITED Calibration Laboratory

Laboratorio CL-101

Aprobó:
Approved by

Christian R. Vaca Marban
Coordinador del Laboratorio

Laboratorio de Metrología en Tiempo y Frecuencia

ESPECIFICACIONES DEL INSTRUMENTO
Instrument specifications

Tacómetro digital multifunciones calibrado en:

Función Function	**Intervalo de medida** Measuring interval	**Error máximo permitido** Maximum permissible error	**Resolución** Resolution
Medición en RPM Contacto	(0.5 a 999.9) RPM	NO APLICA	0.1 RPM
	(1 000 a 19 999) RPM		1 RPM

PATRONES DE REFERENCIA
Reference standards

Instrumento / Instrument		**Identificación** / ID number
REFERENCIA DE TIEMPO Y FRECUENCIA GPS		TF01.05
Marca / Brand name	**Modelo** / Model	**Número de serie** / Serial number
HEWLETT PACKARD	58503A	3504A00226
Incertidumbre / Uncertainty	**Calibró** / Calibrated by	**Número de certificado** / Certificate number
1,48 partes en 10^{11} ± 5 partes en 10^{14} para un tiempo de promediación t= 8 s	CENAM	CNM-CC-430-002/2022
Fecha de calibración / Calibration date	**Próxima calibración** / Next calibration	**Trazabilidad** / Traceability
2022-02-14	2024-02-14	CENAM

Instrumento / Instrument		**Identificación** / ID number
SINTETIZADOR GENERADOR DE FUNCIONES		TF03.02
Marca / Brand name	**Modelo** / Model	**Número de serie** / Serial number
HEWLETT PACKARD	3325B	2847A05134
Incertidumbre / Uncertainty	**Calibró** / Calibrated by	**Número de certificado** / Certificate number
1,48 partes en 10^{11} ± 5 partes en 10^{14} para un tiempo de promediación t= 8 s	INYMET, S.A. de C.V.	IMF-0595-2021
Fecha de calibración / Calibration date	**Próxima calibración** / Next calibration	**Trazabilidad** / Traceability
2022-08-04	2023-09-04	CENAM

TRAZABILIDAD DE LA MEDICIÓN
Measurement traceability

Los resultados de calibración emitidos son trazables al Sistema Internacional de Unidades (SI), a través de una cadena ininterrumpida de calibraciones vinculadas a patrones primarios, mantenidos por el Centro Nacional de Metrología (CENAM) o a otro Laboratorio Primario Nacional reconocido internacionalmente (NIST, NRC, NPL, PTB, etc.).

Algunas mediciones pueden ser trazables a constantes físicas fundamentales o a patrones de medición por consenso. La documentación de soporte relativa a la trazabilidad de la medición está disponible para su revisión en nuestro Laboratorio a través de una cita previa.

VALIDEZ Y RECONOCIMIENTO DE LA ACREDITACIÓN
Validity and recognition of the accreditation

Este Laboratorio está acreditado de acuerdo con la reconocida norma internacional ISO/IEC 17025. Esta acreditación demuestra la competencia técnica para un alcance definido y la operación del Laboratorio con un Sistema de Gestión de la Calidad. (Refiérase al comunicado conjunto de ISO-ILAC-IAF fechado en abril de 2017 al siguiente vínculo:
https://www.nist.gov/system/files/documents/2017/07/05/joint-iso-iec-17025-communique-2017-final-signed_1.pdf

INyMET, S.A. de C.V. está acreditado con el número de certificado CL-101, el cual fue emitido por el organismo de acreditación denominado International Accreditation Service, Inc. (IAS). El certificado con el alcance definido de las magnitudes acreditadas puede ser consultado en el sitio web:
https://www.iasonline.org/wp-content/uploads/2017/05/CL-101-Cert-New.pdf

Laboratorio de Metrología en Tiempo y Frecuencia

International Accreditation Service, Inc. (IAS) es uno de los organismos de acreditación de laboratorios de calibración que han firmado el Acuerdo de Reconocimiento Mutuo llamado ILAC MRA, por sus siglas en inglés (Mutual Recognition Arrangement of International Laboratory Accreditation Cooperation), el cual permite la aceptación de los Certificados de Calibración a través de las fronteras nacionales de los países signatarios. En el sitio web de ILAC en: https://www.ilac.org se pueden encontrar mayores detalles del ILAC MRA y la lista de signatarios se consulta en: https://ilac.org/ilac-mra-and-signatories/

RESULTADOS DE LA CALIBRACIÓN

Calibration results

MEDICIÓN EN RPM (CONTACTO) :

IBC = Instrumento Bajo Calibración

Patrón		IBC	Sesgo instrumental	Incertidumbre	
Frecuencia Hz	Equivalencia RPM	RPM	RPM	Equivalencia RPM	Frecuencia Hz
0.133 333	1.0	1.00	0.00	± 0.073	9.781E-03
0.266 667	2.0	2.00	0.00	± 0.073	9.781E-03
0.666 667	5.0	5.00	0.00	± 0.073	9.781E-03
1.333 333	10.0	9.90	0.10	± 0.073	9.781E-03
2.666 667	20.0	19.90	0.10	± 0.073	9.781E-03
6.666 667	50.0	49.90	0.10	± 0.073	9.781E-03
13.333 333	100.0	99.90	0.10	± 0.073	9.781E-03
26.666 667	200.0	199.90	0.10	± 0.073	9.781E-03
66.666 667	500.0	499.90	0.10	± 0.734	9.781E-02
133.333 333	1 000.0	1 000.00	0.00	± 0.734	9.781E-02
266.666 667	2 000.0	1 999.00	1.00	± 0.734	9.781E-02
666.666 667	5 000.0	5 003.00	-3.00	± 0.734	9.781E-02
1 333.333 333	10 000.0	10 000.00	0.00	± 0.734	9.781E-02
2 665.333 333	19 990.0	19 989.00	1.00	± 0.734	9.781E-02

OBSERVACIONES Y CONCLUSIONES

Notes and conclusions

La estimación de la incertidumbre de medición se realizó en base a la guía JCGM 100:2008, GUM 1995 with minor corrections "Evaluation of measurement data - Guide to the expression of uncertainty in measurement", con un factor de cobertura de k = 2 (nivel de confianza del 95,45 %).

El instrumento no requirió ajuste.

Para obtener la equivalencia del PATRÓN en RPM a partir de Hz:

$$RPM = \frac{1}{min} = \frac{1}{min} * \frac{1\ min}{60\ s} = \frac{1}{60\ s} = \frac{1}{60}\ Hz$$

Por lo tanto:

PATRÓN EN RPM = (Frecuencia en Hz * 60) RPM

Para obtener la equivalencia del PATRÓN en RPM (Contacto) a partir de Hz: El instumento cuenta con un encoder de 8 pulsos por RPM.

$$RPM = \frac{1}{min} * N\ pulsos/vuelta = \frac{1}{min} * \frac{1\ min}{60\ s} * 8 = \frac{1}{10} = 0.133\ 333\ 333\ Hz$$

Por lo tanto:

PATRÓN EN RPM = (Frecuencia en Hz * 10) RPM

El presente certificado de calibración sólo ampara las mediciones reportadas. Es responsabilidad del usuario determinar el uso adecuado de éstos resultados.

Fin del certificado.

INYMET, S.A. DE C.V.
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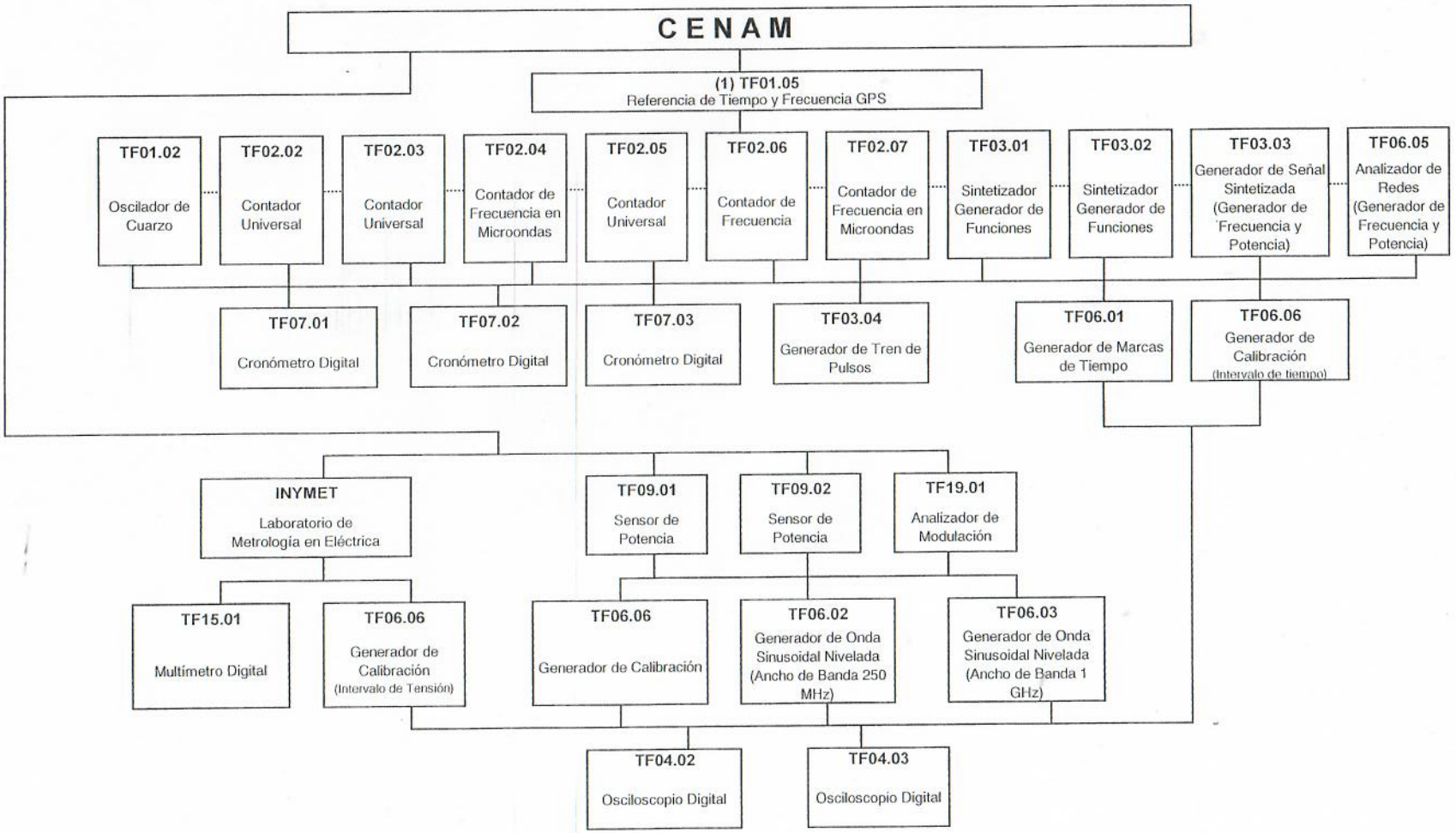
CADENA DE DE TRAZABILIDAD METROLÓGICA
LABORATORIO DE METROLOGÍA EN TIEMPO Y FRECUENCIA



(1) Base de tiempo de referencia.

CERTIFICATE OF ACCREDITATION

This is to attest that

INYMET

SALVATIERRA NO. 32-5, COL SAN BARTOLO ATEPEHUACAN
GUSTAVO A MADERO, 07730, UNITED MEXICAN STATES (MEXICO)

Calibration Laboratory CL-101

has met the requirements of AC204, *IAS Accreditation Criteria for Calibration Laboratories*, and has demonstrated compliance with ISO/IEC Standard 17025:2017, *General requirements for the competence of testing and calibration laboratories.* This organization is accredited to provide the services specified in the scope of accreditation.

Effective Date April 6, 2021

Expiration Date April 1, 2024

President

Visit www.iasonline.org for current accreditation information.

SCOPE OF ACCREDITATION

International Accreditation Service, Inc.

3060 Saturn Street, Suite 100, Brea, California 92821, U.S.A. | www.iasonline.org

INYMET

Contact Name LAI. Alejandra Gonzalez **Contact Phone** + 52 55-5754-3087 ext. 211

Accredited to ISO/IEC 17025:2017 *Effective Date April 6, 2021*

CALIBRATION AND MEASUREMENT CAPABILITY (CMC)*

MEASURED QUANTITY or DEVICE TYPE CALIBRATED	RANGE	UNCERTAINTY[1,2] (±)	CALIBRATION PROCEDURE AND/OR STANDARD EQUIPMENT USED
Dimensional			
Calipers (Vernier and dial)	Up to 100 mm Up to 1000 mm	11 µm 20 µm	Direct Comparison Method Gauge blocks
Calipers (Digital-electronic)	Up to 150 mm Up to 300 mm Up to 600 mm	8 µm 10 µm 12 µm	Direct Comparison Method Gauge blocks
Outside Micrometers	Up to 25 mm Up to 50 mm Up to 300 mm	0.7 µm 0.8 µm 12 µm	Direct Comparison Method Gauge blocks
Inside Micrometer	5 mm to 30 mm 50 mm to 300 mm	8 µm 10 µm	Direct Comparison Method Gauge blocks & gauge block holder
Depth Micrometer	Up to 100 mm	7.5 µm	Direct Comparison Method Gauge blocks
Height Gauges (Vernier & dial type)	Up to 300 mm Up to 600 mm Up to 1000 mm	15 µm 18 µm 20 µm	Direct Comparison Method Gauge blocks, long gauge blocks and electronic pick-up
Height Gauges (Digital-electronic)	Up to 600 mm Up to 1.000 mm	2 µm 3.5 µm	Direct Comparison Method Gauge blocks
Dial Indicators (Plunger Type) Electronic Mechanical	Up to 25 mm Up to 100 mm Up to 10 mm	1.0 µm 2.6 µm 8 µm	Direct Comparison Method Gauge blocks
Dial Indicator (Lever Type)	Up to 0.14 mm Up to 0.2 mm Up to 2 mm	1 µm 1.5 µm 8 µm	Direct Comparison Method Gauge blocks Electrical comparator

** If information in this CMC is presented in non-SI units, the conversion factors stated in NIST Special Publication 811 "Guide for the Use of the International System of Units (SI)" apply.*

MEASURED QUANTITY or DEVICE TYPE CALIBRATED	RANGE	UNCERTAINTY[1,2] (±)	CALIBRATION PROCEDURE AND/OR STANDARD EQUIPMENT USED
Electrical Comparator (Analog / Digital Display)	Up to 50 mm	0.4 µm	Direct Comparison Method Gauge blocks
End Standards	Up to 25 mm 25 mm to 50 mm 50 mm to 100 mm 100 mm to 200 mm 200 mm to 500 mm 500 mm to 1000 mm	1 µm 1.5 µm 2 µm 2.5 µm 3.8 µm 7 µm	Direct Comparison Method Gauge blocks, long gauge blocks and electronic pick-up
Scales/Steel Rules/Steel Tapes	Up to 1 m Up to 50 m	0.3 mm (0.5 + 0.02L) mm Where L is in meters	Direct Comparison Method Standard Ruler Standard glass scale & reticles, Vernier Caliper 1m
Feeler Gauges	Up to 1 mm 1 mm to 2 mm	1.2 µm 2.0 µm	Direct Comparison Method Micrometer (digital)
Bevel Protractor Analog / Digital	Up to 360°	5’	Direct Comparison Method Angle Gauges
Surface Plate	Up to 1600 mm x 1000 mm	10 µm	Direct Comparison Method Using precision level of 0.02 mm/m sensitivity
Mechanical			
Pressure Gauges Absolute	1.24 kPa to 62.16 kPa 5 inH_2O to 250 inH_2O	0.025 % 0.025 %	Direct Comparison Method Pressure Balance
	Up to 7.5 kPa Up to 30 inH_2O	0.05 % FS 0.05 % FS	Direct Comparison Method Pressure Transducer, Pressure Calibrator.
	21 kPa to 700 kPa (3 psig to 100 psig)	0.015 %	Direct Comparison Method Pressure Balance,
	70 kPa to 7000 kPa (10 psig to 1000 psig)	0.015 %	Direct Comparison Method Pressure Balance
	1380 kPa to 70 MPa (200 psig to 10000 psig)	0.01 %	Direct Comparison Method Pressure Balance
	Up to 2000 psi	0.025 % FS	Direct Comparison Method Pressure Transducer, Pressure Calibrator
	Up to 10000 psi	0.025 % FS	Direct Comparison Method Pressure Transducer
	206.84 kPa to 2068.4 kPa (30 psig to 300 psig)	0.025 % FS	Direct Comparison Method Pressure Calibrator
	10 kPa to 110 kPa	0.01 % FS	Direct Comparison Method Pressure Calibrator
Vacuum and Pressure	Up to -100 kPa Up to -1 bar	0.01 % FS	Direct Comparison Method Pressure Calibrator

MEASURED QUANTITY or DEVICE TYPE CALIBRATED	RANGE	UNCERTAINTY[1,2] (±)	CALIBRATION PROCEDURE AND/OR STANDARD EQUIPMENT USED
Vacuum and Pressure continued	-101 kPa to 207 kPa (-14 psi to 30 psi)	0.025 % FS	Direct Comparison Method Pressure Calibrator
Volume – Glass	100 µL to 5 mL	0.30 %	Gravimetric Method Electronic Balance, Automatic Micropipette
	1 mL to 150 mL 150 mL to 4000 mL 4L to 20 L	0.07 % 0.16 % 0.16 %	Gravimetric Method Electronic Balance, Glassware
Volume - Metal	2L to 20 L 20 L to 500 L	0.017 % 0.02 %	Gravimetric Method Electronic Balance
	20 L to 50 L 50 L to 200 L	0.023 % 0.03 %	Direct Transfer Method Volumetric Standard
	200 L to 5000 L	0.03 %	Direct Transfer Method Dual Rotor Turbine, Coriolis Meter, Volumetric Standard
	5000 L to 1,000,000 L	0.12 %	Direct Transfer Method Dual Rotor Turbine Meter, Coriolis Meter.
	200,000 L to 50,000,000 L	0.5 %	Geometric Method Measuring Tape Metric Square
Liquid Flow By Total Mass	10 kg to 24 kg 20 kg to 500 kg	0.10 % 0.10 %	Gravimetric Method Electronic Balance
	2 kg to 5 x 10^6 kg	0.15 %	Against Ref Std. (in lab or in field) Flowmeter
Liquid Flow By Total Volume	10 L to 500 L	0.12%	Gravimetric Method Electronic Balance
	2 L to 5 x 10^6 L	0.20%	Against Ref Std. (in lab or in field) Flowmeter
Liquid Flow Rate Mass per Unit Time	0.001 g/min to 200 g/min 100 g/min to 8 kg/min 1 kg/min to 24 kg/min 20 kg/min to 1000 kg/min	0.35% 0.35% 0.40% 0.40%	Gravimetric Method Electronic Balance
	2 kg/min to 1000 kg/min	0.15%	Against Ref. Std. (in lab or field) Flowmeter
Liquid Flow Rate Volume per Unit Time	0.1 mL/min to 200 mL/min 100 mL/min to 8 L/min 1 L/min to 24 L/min 20 L/min to 1000 L/min	0.35% 0.35% 0.35% 0.35%	Gravimetric Method Electronic Balance

MEASURED QUANTITY or DEVICE TYPE CALIBRATED	RANGE	UNCERTAINTY[1,2] (±)	CALIBRATION PROCEDURE AND/OR STANDARD EQUIPMENT USED
Liquid Flow Rate Volume per Unit Time continued	2 L/min to 1000 L/min	0.20 %	Against Ref Std. (in lab or in field) Flowmeter
Gas Flow By Total Mass	0.001 g to 200 g 0.1 g to 8000 g 1.0 kg to 24 kg	0.30% 0.30% 0.40%	Gravimetric Method Electronic Balance
	100 mg to 5 x 10^6 kg	0.40 %	Against Ref. Std. (in lab or field) Flowmeter
Gas Flow By Total Volume	0.001 L to 200 L 0.1 L to 8000 L 1000 L to 24000 L	0.35 % 0.35 % 0.40%	Gravimetric Method Electronic Balance
	1 mL to 5 x 10^6 L	0.40 %	Against Ref. Std. (in lab or field) Flowmeter
Gas Flow Rate Mass per Unit Time	0.001 g/min to 10 g/min	0.35 %	Gravimetric Method Electronic Balance
	2,0 g/min to 500 g/min	0.35%	Gravimetric Method Electronic Balance
	1 kg/min to 5 kg/min	0.35%	Gravimetric Method Electronic Balance
	50 mg/min to 1000 kg/min	0.15%	Against Ref Std. (in lab or field) Flowmeter
Gas Flow Rate Volume per Unit Time	0.1 mL/min to 10 L/min 2.0 L/min to 500 L/min 100 L/min to 5000 L/min	0.35% 0.35% 0.35%	Gravimetric Method Electronic Balance
	50 mL/min to 1000 L/min	0.40 %	Against Ref. Std. (in lab or field) Flowmeter
Torque Wrenches	0 N·m to 25 N·m 25 N·m to 160 N·m 160 N·m to 1000 N·m	0.075 N·m 0.48 N·m 3.0 N·m	Direct Comparison Method 25 N·m Transducer 160 N·m Transducer 1000 N·m Transducer
Torque Analyzers and Torque Transducers	0 N·m to 10 N·m 10 N·m to 100 N·m 100 N·m to 1000 N·m	0.006 N·m 0.04 N·m 0.5 N·m	Direct Comparison Method Balance Arms: 1 m, 0.5 m, 0.1 m & Wheel: 0.1m 1000 N·m Transducer Balance Arms: 1 m & Wheel: 0.1m Mass sets: 1g to 5kg and 10 kg to 100 kg

MEASURED QUANTITY or DEVICE TYPE CALIBRATED	RANGE	UNCERTAINTY[1,2] (±)	CALIBRATION PROCEDURE AND/OR STANDARD EQUIPMENT USED
Vibration Transducer Sensitivity or Vibration of Meter (10 Hz to 10 kHz)	0.1 m/s^2 to 98 m/s^2	1 %	Direct Comparison Method Portable Accelerometer Calibrator
Thermal			
PRT	-80 ºC to 660 ºC	0.01 °C	Direct Comparison Method Precision Thermometry Bridge with RTD
Thermocouples (J,K,R,S,T,B)	0 ºC to 1000 ºC	0.5 ºC	Indirect Comparison Method Thermocouple and Digital Multimeter or Digital Thermometer
Thermocouples type J, K, T, R, S, B or RTD or Thermistor with Digital or Analog Readouts	-80 ºC to 600 ºC	0.03 °C	Direct Comparison Method Digital Thermometer
Forced convection ovens and furnaces	Up to 300 ºC	1.5 ºC	Direct Comparison Method Energy Meter and Digital Thermometer with 12 T-type TCs
Infrared Thermometers	-38 ºC to 500 ºC	0.3 %	Direct Comparison Method IR Calibrator, Digital Thermometer and RTD or Thermocouple
Liquid in Glass Thermometer	-38 ºC to 250 ºC	0.07 °C	Direct Comparison Method Digital Thermometer or similar
Humidity Generate[3]	25 %RH to 90 %RH (15 ºC to 50 ºC)	0.61 %RH	Direct Comparison Method General Eastern Hygrometer, Humidity Chamber
Humidity Measure[4]	5 %RH to 95 %RH (5 ºC to 100 ºC)	0.39 %RH	Direct Comparison Method General Eastern Hygrometer
Electrical – DC/LF			
DC Voltage – Generate[3]	1 V 10 V	0.5 ppm 0.5 ppm	Transfer Method Zener Reference
	0 mV to 330 mV 330 mV to 3.3 V 3.3 V to 33 V 33 V to 330 V 100 V to 1020 V	60 µV/V + 3 µV 50 µV/V + 5 µV 50 µV/V + 50 µV 55 µV/V + 500 µV 55 µV/V + 1.5 mV	Direct Method Multifunction Calibrator

MEASURED QUANTITY or DEVICE TYPE CALIBRATED	RANGE	UNCERTAINTY[1,2] (±)	CALIBRATION PROCEDURE AND/OR STANDARD EQUIPMENT USED
DC Voltage – Generate[3] continued	0 mV to 12 V	0.004 % RDG + 0.004 % RNG	Direct Method Multifunction Calibrator
	0.1 mV to 110 mV 110 mV to 1.1 V 1.1 V to 19.5 V 19.5 V to 110 V 110 V to 1100 V	3 µV/V 1.5 µV/V 1.5 µV/V 2 µV/V 2 µV/V	Replacement Method Multi-standard transfer with Vcc Source
DC Voltage – Measure[4]	0 mV to 100 mV 100 mV to 1 V 1 V to 10 V 10 V to 100 V	9 µV/V RDG + 3 µV/V RNG 8 µV/V RDG + 0.3 µV/V RNG 8 µV/V RDG + 0.05 µV/V RNG 10 µV/V RDG + 0.3 µV/V RNG	Direct Method Digital Multimeter
	100 V to 1000 V	10 µV/V RDG + 0.1 µV/V RNG	Direct Method Digital Multimeter
	0 mV to 100 mV 100 mV to 60 V	0.004 % RDG + 0.004 % RNG 0.01 % RDG + 0.006 % RNG	Direct Method Multifunction Calibrator
	0.1 mV to 110 mV 110 mV to 1.1 V 1.1 V to 19.5 V 19.5 V to 110 V 110 V to 1100 V	3 µV/V 1.5 µV/V 1.5 µV/V 2 µV/V 2 µV/V	Direct Method Multi-standard transfer
DC Current – Generate[3]	0 mA to 3.3 mA 3.3 mA to 33 mA 33 mA to 330 mA 330 mA to 2.2 A 2.2 A to 11 A	130 µA/A + 50 nA 100 µA/A + 0.25 µA 100 µA/A + 3.3 µA 300 µA/A + 44 µA 600 µA/A + 330 µA	Direct Method Multifunction Calibrator
	20 A to 1000 A	0.6 %	Direct Method Multifunction Calibrator with 100-turn coil
	0 mA to 24 mA	0.025 % FS	Direct Method Multifunction Calibrator
	0.1 µA to 110 µA 0.11 mA to 1.1 mA 1.1 mA to 11 mA 11 mA to 110 mA 110 mA to 1.1 A 1.1 A to 11 A	7 µA/A 7 µA/A 7 µA/A 7 µA/A 15 µA/A 20 µA/A	Replacement Method Multi-standard transfer with Current Source
DC Current –Measure[4]	0 nA to 100 nA 100 nA to 1 µA	30 µA/A RDG + 400 µA/A RNG 20 µA/A RDG + 40 µA/A RNG	Direct Method Digital Multimeter

MEASURED QUANTITY or DEVICE TYPE CALIBRATED	RANGE	UNCERTAINTY[1,2] (±)	CALIBRATION PROCEDURE AND/OR STANDARD EQUIPMENT USED
DC Current –Measure[4] continued	1 µA to 10 µA 10 µA to 100 µA 0.1 mA to 10 mA 10 mA to 100 mA 100 mA to 1 A	20 µA/A RDG + 10 µA/A RNG 20 µA/A RDG + 8 µA/A RNG 20 µA/A RDG + 5 µA/A RNG 35 µA/A RDG + 5 µA/A RNG 110 µA/A RDG + 10 µA/A RNG	Direct Method Digital Multimeter
	0.1 µA to 110 µA 0.1 mA to 1.1 mA 1.1 mA to 11 mA 11 mA to 110 mA 110 mA to 1.1 A 1.1 A to 11 A	7 µA/A 7 µA/A 7 µA/A 7 µA/A 15 µA/A 20 µA/A	Direct Method Multi-standard transfer
	0 mA to 52 mA	0.005 % RDG + 0.01 % RNG	Indirect Method Shunt with Digital Multimeter
	1 A to 75 A	0.01 %	Indirect Method Shunt with Digital Multimeter
AC Current Generate[3]	0.03 mA to 0.33 mA (45 Hz to 1 kHz) (1 kHz to 5 kHz) (5 kHz to 10 kHz) 0.33 mA to 3.3 mA (45 Hz to 1 kHz) (1 kHz to 5 kHz) (5 kHz to 10 kHz) 3.3 mA to 33 mA (45 Hz to 1 kHz) (1 kHz to 5 kHz) (5 kHz to 10 kHz) 33 mA to 330 mA (45 Hz to 1 kHz) (1 kHz to 5 kHz) (5 kHz to 10 kHz) 330 mA to 2.2 A (45 Hz to 1 kHz) (1 kHz to 5 kHz) 2.2 A to 11 A (45 Hz to 65 Hz) (65 Hz to 500 kHz) (500 Hz to 1 kHz)	 0.13 % + 0.25 µA 0.4 % + 0.15 µA 1.3 % + 0.15 µA 0.1 % + 0.3 µA 0.2 % + 0.3 µA 0.6 % + 0.3 µA 0.09 % + 3 µA 0.2 % + 3 µA 0.6 % + 3 µA 0.09 % + 30 µA 0.2 % + 30 µA 0.6 % + 30 µA 0.1 % + 300 µA 0.75 % + 300 µA 0.06 % + 2 mA 0.10 % + 2 mA 0.33 % + 2 mA	Direct Method Multifunction Calibrator

MEASURED QUANTITY or DEVICE TYPE CALIBRATED	RANGE	UNCERTAINTY[1,2] (±)	CALIBRATION PROCEDURE AND/OR STANDARD EQUIPMENT USED
AC Current Generate[3] continued	20 A to 750 A (50 Hz/60 Hz)	 1 %	Direct Method Multifunction Calibrator with 100-turn coil
	90 µA to 110 µA (36 Hz to 1.1 kHz) (4.5 kHz to 5.5 kHz) (9 kHz to 11 kHz) 0.9 mA to 1.1 A (36 Hz to 1.1 kHz) (4.5 kHz to 5.5 kHz) (9 kHz to 11 kHz) 9 A to 11 A (36 Hz to 1.1 kHz) (4.5 kHz to 5.5 kHz) (9 kHz to 11 kHz) (18 kHz to 22 kHz)	 50 µA/A 100 µA/A 300 µA/A 40 µA/A 70 µA/A 200 µA/A 200 µA/A 300 µA/A 600 µA/A 1000 µA/A	Replacement Method Multi-standard transfer with Current Source
AC Current – Measure[4]	90 µA to 110 µA (36 Hz to 1.1 kHz) (4.5 kHz to 5.5 kHz) (9 kHz to 11 kHz) 0.9 mA to 1.1 A (36 Hz to 1.1 kHz) (4.5 kHz to 5.5 kHz) (9 kHz to 11 kHz) 9 A to 11 A (36 Hz to 1.1 kHz) (4.5 kHz to 5.5 kHz) (9 kHz to 11 kHz) (18 kHz to 22 kHz)	 50 µA/A 100 µA/A 300 µA/A 40 µA/A 70 µA/A 200 µA/A 200 µA/A 300 µA/A 600 µA/A 1000 µA/A	Direct Method Multi-standard transfer
AC Voltage Generate[3]	1 mV to 33 mV (45 Hz to 10 kHz) (10 kHz to 20 kHz) (20 kHz to 50 kHz) (50 kHz to 100 kHz) (100 kHz to 500 kHz) 33 mV to 330 mV (45 Hz to 10 kHz) (10 kHz to 20 kHz) (20 kHz to 50 kHz) (50 kHz to 100 kHz) (100 kHz to 500 kHz)	 0.15 % + 20 µV 0.2 % + 20 µV 0.25 % + 20 µV 0.35 % + 33 µV 1 % + 60 µV 0.05 % + 20 µV 0.1 % + 20 µV 0.16 % + 40 µV 0.24 % + 170 µV 0.7 % + 330 µV	Direct Method Multifunction Calibrator

MEASURED QUANTITY or DEVICE TYPE CALIBRATED	RANGE	UNCERTAINTY[1,2] (±)	CALIBRATION PROCEDURE AND/OR STANDARD EQUIPMENT USED
AC Voltage Generate[3] continued	330 mV to 3.3 V (45 Hz to 10 kHz) (10 kHz to 20 kHz) (20 kHz to 50 kHz) 330 mV to 3.3 V (50 kHz to 100 kHz) (100 kHz to 500 kHz) 3.3 V to 33 V (45 Hz to 10 kHz) (10 kHz to 20 kHz) (20 kHz to 50 kHz) (50 kHz to 100 kHz) 33 V to 330 V (45 Hz to 1 kHz) (1 kHz to 10 kHz) (10 kHz to 20 kHz) 330 V to 1020 V (45 Hz to 1 kHz) (1 kHz to 5 kHz) (5 kHz to 10 kHz)	 0.03 % + 60 µV 0.08 % + 60 µV 0.14 % + 300 µV 0.24 % + 1.7 mV 0.5 % + 3.3 mV 0.04 % + 600 µV 0.08 % + 2.6 mV 0.19 % + 5 mV 0.24 % + 17 mV 0.5 % + 6.6 mV 0.08 % + 15mV 0.09 % + 33 mV 0.05 % + 80 mV 0.20 % + 100 mV 0.20 % + 500 mV	Direct Method Multifunction Calibrator continued
	0.9 mV to 110 mV (36 Hz to 33 kHz) (45 kHz to 55 kHz) (90 kHz to 110 kHz) (270 kHz to 330 kHz) (450 kHz to 550 kHz) 0.9 V to 11 V (270 kHz to 330 kHz) (450 kHz to 550 kHz) 0.9 V to 110 V (36 Hz to 33 kHz) (45 kHz to 55 kHz) (90 kHz to 110 kHz) 90 V to 110 V (180 kHz to 220 kHz) 110 V to 1100 V (36 Hz to 33 kHz)	 20 µV/V + 2 µV 30 µV/V + 2 µV 50 µV/V + 3 µV 100 µV/V + 3 µV 200 µV/V + 3 µV 70 µV/V 100 µV/V 10 µV/V 20 µV/V 30 µV/V 50 µV/V 15 µV/V	Replacement Method Multi-standard transfer with Voltage Source

MEASURED QUANTITY or DEVICE TYPE CALIBRATED	RANGE	UNCERTAINTY[1,2] (±)	CALIBRATION PROCEDURE AND/OR STANDARD EQUIPMENT USED
AC Voltage Measure[4]	0.9 mV to 110 mV (36 Hz to 33 kHz) (45 kHz to 55 kHz) (90 kHz to 110 kHz) (270 kHz to 330 kHz) (450 kHz to 550 kHz) 0.9 V to 11 V (270 kHz to 330 kHz) (450 kHz to 550 kHz) 0.9 V to 110 V (36 Hz to 33 kHz) (45 kHz to 55 kHz) (90 kHz to 110 kHz) 90 V to 110 V (180 kHz to 220 kHz) 110 V to 1100 V (36 Hz to 33 kHz)	 20 µV/V + 2 µV 30 µV/V + 2 µV 50 µV/V + 3 µV 100 µV/V + 3 µV 200 µV/V + 3 µV 70 µV/V 100 µV/V 10 µV/V 20 µV/V 30 µV/V 50 µV/V 15 µV/V	Direct Method Multi-standard transfer
DC Resistance – Generate[3]	1 Ω 10 Ω 1 kΩ 10 kΩ	8.0 µΩ/Ω 2 µΩ/Ω 2 µΩ/Ω 2 µΩ/Ω	Direct Method Indirect Method Resistances Standard
	100 µΩ 1 mΩ 10 mΩ 100 mΩ 1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ	30 µΩ/Ω 10 µΩ/Ω 10 µΩ/Ω 3 µΩ/Ω 2 µΩ/Ω 2 µΩ/Ω 2 µΩ/Ω 2 µΩ/Ω 2 µΩ/Ω	Direct Method Indirect Method Calibration Resistors
	0.1 Ω to 1 Ω 1 Ω to 10 Ω 10 Ω to 100 Ω 100 Ω to 100 kΩ 100 kΩ to 1 MΩ 1 MΩ to 10 MΩ 10 MΩ to 100 MΩ 100 MΩ to 1 GΩ	200 µΩ/Ω 35 µΩ/Ω 26 µΩ/Ω 15 µΩ/Ω 22 µΩ/Ω 80 µΩ/Ω 550 µΩ/Ω 0.6 %	Replacement Method Digital Multimeter with Decade Resistors
	0.1 Ω to 1 Ω 1 Ω to 10 Ω 10 Ω to 100 Ω 100 Ω to 1 kΩ 1 kΩ to 1 MΩ	1 % 0.1 % 0.01 % 0.03 % 0.01 %	Direct Method Decade Resistors

MEASURED QUANTITY or DEVICE TYPE CALIBRATED	RANGE	UNCERTAINTY[1,2] (±)	CALIBRATION PROCEDURE AND/OR STANDARD EQUIPMENT USED
DC Resistance – Generate[3] continued	0.01 Ω to 0.1 Ω 0.1 Ω to 1 Ω 1 Ω to 10 Ω 10 Ω to 100 Ω 100 Ω to 10 MΩ	7 % 0.7 % 0.10 % 0.04 % 0.03 %	Direct Method Decade Resistors
	0.1 Ω to 2 Ω 2 Ω to 4 Ω 9 Ω to 19.5 Ω 20 Ω to 195 Ω 0.2 kΩ to 1.95 kΩ 2 kΩ to 19.5 kΩ 20 kΩ to 195 kΩ 0.2 MΩ to 1.95 MΩ 2 MΩ to 19.5 MΩ 20 MΩ to 110 MΩ	20 μΩ/Ω 15 μΩ/Ω 5 μΩ/Ω 3 μΩ/Ω 3 μΩ/Ω 3 μΩ/Ω 5 μΩ/Ω 8 μΩ/Ω 12 μΩ/Ω 180 μΩ/Ω	Replacement Method Multi-standar transfer with Resistance generator
DC Resistance – Measure[4]	0.1 Ω to 10 Ω 10 Ω to 100 Ω 100 Ω to 100 kΩ 100 kΩ to 1 MΩ 1 MΩ to 10 MΩ 10 MΩ to 100 MΩ 100 MΩ to 1 GΩ	20 μΩ/Ω 17 μΩ/Ω 11 μΩ/Ω 17 μΩ/Ω 60 μΩ/Ω 510 μΩ/Ω 0.6 %	Direct Method Digital Multimeter
	0.1 Ω to 2 Ω 2 Ω to 4 Ω 9 Ω to 19.5 Ω 20 Ω to 195 Ω 0.2 kΩ to 1.95 kΩ 2 kΩ to 19.5 kΩ 20 kΩ to 195 kΩ 0.2 MΩ to 1.95 MΩ 2 MΩ to 19.5 MΩ 20 MΩ to 110 MΩ	20 μΩ/Ω 15 μΩ/Ω 5 μΩ/Ω 3 μΩ/Ω 3 μΩ/Ω 3 μΩ/Ω 5 μΩ/Ω 8 μΩ/Ω 12 μΩ/Ω 180 μΩ/Ω	Direct Method Multi-standar transfer
RF/Microwave and Electromagnetics			
AC Power – Measure[4]	-30 dBm to 20 dBm (10 Hz to 1 MHz)	0.01 dB	Direct method Multimeter Power meter + power sensor
AC Power – Generate[3]	-30 dBm to 20 dBm (10 Hz to 1 MHz)	0.01 dB	Direct method Multimeter Power meter + power sensor
Frequency – Measure[4] (Pulse, Square or Sinusoidal Signal)	In laboratory: 500 MHz to 18 GHz	4.7×10^{-11}	Direct method Primary time base + universal counter
	At customer site: 500 MHz to 18 GHz	2.0×10^{-9}	Direct method Primary time base + universal counter

MEASURED QUANTITY or DEVICE TYPE CALIBRATED	RANGE	UNCERTAINTY[1,2] (±)	CALIBRATION PROCEDURE AND/OR STANDARD EQUIPMENT USED
Frequency – Generate[3] (Pulse, Square or Sinusoidal Signal)	In laboratory: 500 MHz to 18 GHz	4.3×10^{-11}	Direct method Primary time base + universal counter
	At customer site: 500 MHz to 18 GHz	3.0×10^{-10}	Direct method Primary time base + universal counter
RF Power – Measure[4]	-60 dBm to -30 dBm (10 MHz to 18 GHz)	0.1 dB	Direct method Power meter + power sensor
	-20 dBm to 15 dBm (100 kHz to 4.2 GHz)	0.1 dB	Direct method Power meter + power sensor
	-30 dBm to 10 dBm (50 MHz to 18 GHz)	0.1 dB	Direct method Power meter + power sensor
Bandwidth – Measure[4]	For reference power of -20 dBm to +10 dBm 50 kHz to 1 GHz	0.2dB	Direct method Leveled sine wave generator
Bandwidth – Measure[4] continued	For reference power of -60 dBm to +10 dBm 1 GHz to 18 GHz	0.1 dB	Direct method Power meter + power sensor
Time and Frequency			
Frequency – Measure[4] (Sine, Square, Pulse Signal)	In laboratory: 1 mHz to <10 Hz	1.5×10^{-5}	Direct method Primary time base + universal counter
	At customer site: 1 mHz to <10 Hz	2.5×10^{-5}	Direct method Primary time base + universal counter
	In laboratory: 10 Hz a 1 kHz 1 kHz to 1 MHz 1 MHz to 200 MHz 200 MHz to 500 MHz	 1.9×10^{-9} 4.3×10^{-10} 1.9×10^{-11} 3.7×10^{-11}	Direct method Primary time base + universal counter
	At customer site: 10 HZ a 1 kHz 1 kHz to 1 MHz 1 MHz to 200 MHz 200 MHz to 500 MHz	 3.7×10^{-7} 3.0×10^{-8} 3.0×10^{-8} 2.0×10^{-9}	Direct method Primary time base + universal counter
Frequency – Generate[3] (Pulse, Sinusoidal, Square Signal)	In laboratory: 1 mHz to 500 MHz	4.3×10^{-11}	Direct method Primary time base + function generator
	At customer site: 1 mHz to 500 MHz	3.0×10^{-10}	Direct method Primary time base + function generator

MEASURED QUANTITY or DEVICE TYPE CALIBRATED	RANGE	UNCERTAINTY[1,2] (±)	CALIBRATION PROCEDURE AND/OR STANDARD EQUIPMENT USED
Period – Measure[4] (Pulse, Sinusoidal, Square Signal)	In laboratory: 1 ns to 1 ms 1 ms to 1 s 1 s to 1000 s	 4.7×10^{-11} 3.0×10^{-7} 3.0×10^{-4}	Direct method Primary time base + universal counter
	At customer site: 1 ns to 1 ms 1 ms to 1 s 1 s to 1000 s	 2.0×10^{-9} 3.0×10^{-7} 3.0×10^{-4}	Direct method Primary time base + universal counter
Period – Generate[3] (Pulse, Sinusoidal, Square Signal)	In laboratory: 1 ns to 1000 s	4.3×10^{-11}	Direct method Primary time base + function generator or time mark generator
	At customer site: 1 ns to 1000 s	3.0×10^{-10}	Direct method Primary time base + function generator or time mark generator
Time Interval – Measure[4]	In laboratory: 1.25 ns to 86400 s	4.7×10^{-11}	Direct method Primary time base + universal counter
	At customer site: 1.25 ns to 86400 s	3.0×10^{-10}	Direct method Primary time base + universal counter
Time Interval – Generate[3]	In laboratory: 1.25 ns to 86400 s	4.3×10^{-11}	Direct method Primary time base + universal counter
	At customer site: 1.25 ns to 86400 s	3.0×10^{-10}	Direct method Primary time base + universal counter
Timers – Measure[4]	At customer site: 10 ms to 86400 s	 0.58 ms	Direct method Chronometer
Bandwidth – Generate[3]	DC to 26 GHz	0.18 dB	Direct method Primary time base + synthesized signal generator

[1]The uncertainty covered by the Calibration and Measurement Capability (CMC) is expressed as the expanded uncertainty having a coverage probability of approximately 95 %. It is the smallest measurement uncertainty that a laboratory can achieve within its scope of accreditation when performing calibrations of a best existing device. The measurement uncertainty reported on a calibration certificate may be greater than that provided in the CMC due to the behavior of the calibration item and other factors that may contribute to the uncertainty of a specific calibration.

[2]When uncertainty is stated in relative terms (such as percent, a multiplier expressed as a decimal fraction or in scientific notation), it is in relation to instrument reading or instrument output, as appropriate, unless otherwise indicated.

[3]Capability is suitable for the calibration of measuring devices in the stated ranges.

[4]Capability is suitable for the calibration of devices intended to generate the indicated quantity in the stated ranges.