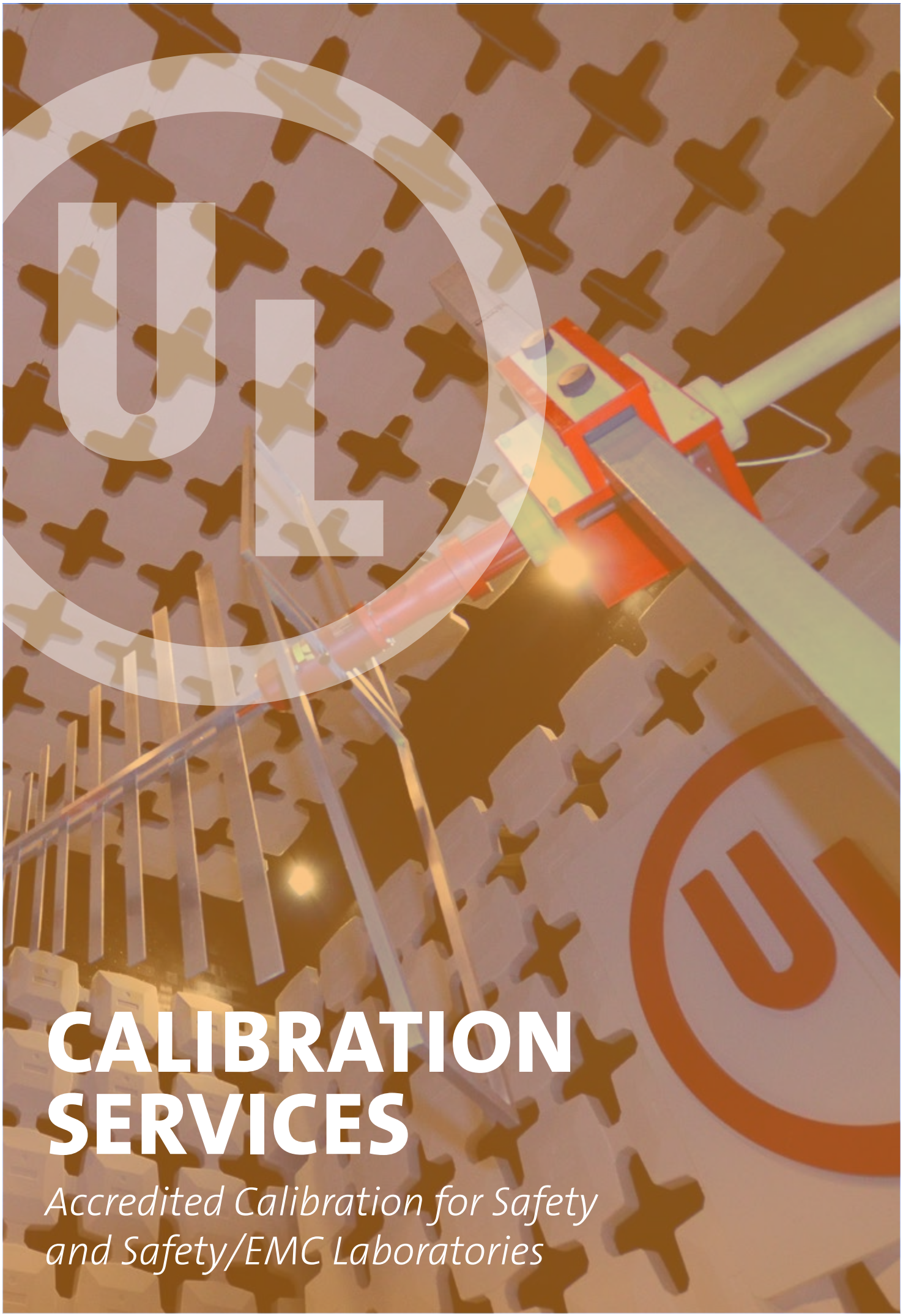
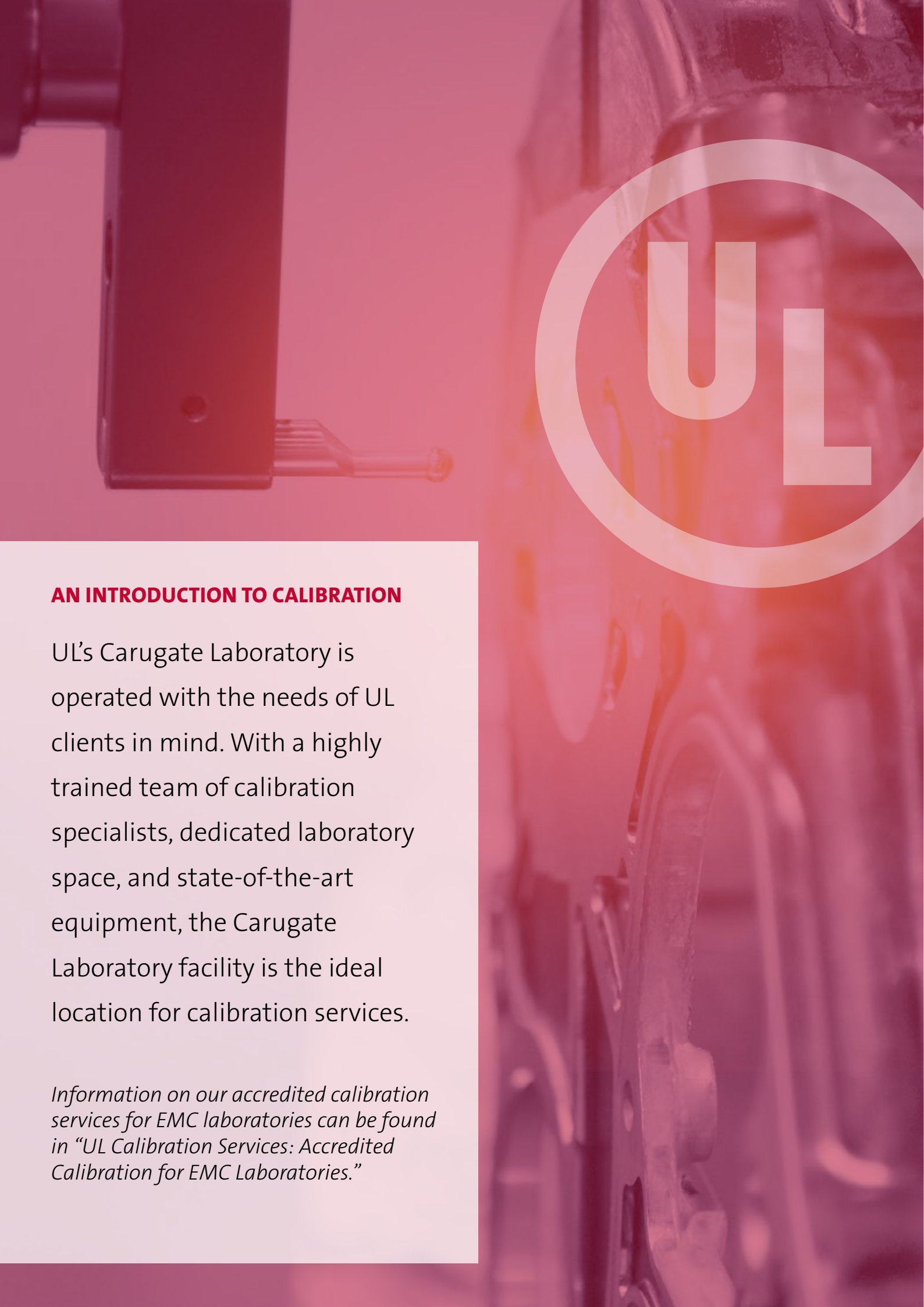


CALIBRATION SERVICES

Accredited Calibration for Safety and Safety/EMC Laboratories



AN INTRODUCTION TO CALIBRATION

UL's Carugate Laboratory is operated with the needs of UL clients in mind. With a highly trained team of calibration specialists, dedicated laboratory space, and state-of-the-art equipment, the Carugate Laboratory facility is the ideal location for calibration services.

Information on our accredited calibration services for EMC laboratories can be found in "UL Calibration Services: Accredited Calibration for EMC Laboratories."

CALIBRATION SERVICES

The Carugate Lab is currently accredited to IECEE, ACCREDIA, OSHA, IAS and more. Proper calibration of sensitive equipment remains a critical part of staying competitive in the global market, and working with a respected, trusted partner like UL can make all the difference.

Understanding Metrological Confirmation

The term "metrological confirmation" typically includes calibration and verification, along with adjustment and/or repair that might be required for equipment found to be outside of a designated range. Equipment calibration and verification are a critical part of ensuring that your laboratory facilities continue to provide accurate results. Due to transit, installation, and the rigors of regular use, even the highest-quality equipment will need initial and routine calibration/verification.

An explanation of metrological confirmation according to the International Organization for Standardization (ISO) is as follows:

Metrological Confirmation <<ISO 10012 Par. 3.5>>

Set of operations required to ensure that measuring equipment conforms to the requirements for its intended use.

NOTE: Metrological conformation generally includes calibration and verification, any necessary adjustment or repair, and subsequent recalibration, comparison with the metrological requirements for the intended use of the equipment, as well as any required sealing and labeling

Calibration <<ISO Guide 99 (VIM) Par. 2.39>>

Operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication.

Verification <<ISO Guide 99 (VIM) Par. 2.44>>

Provision objective evidence that a given item fulfills specified requirements.

Adjustment of a Measuring System <<ISO Guide 99 (VIM) Par. 3.11>>

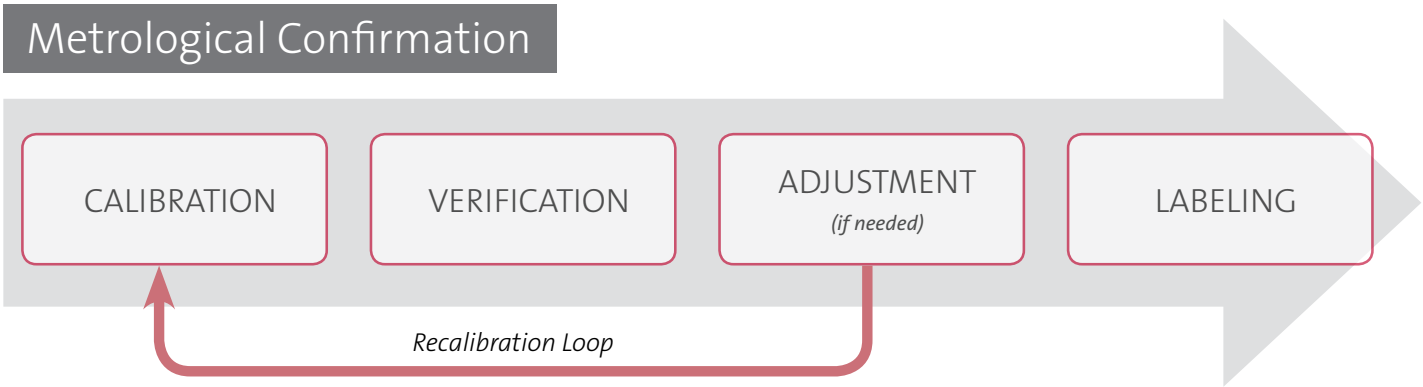
Set of operations carried out on a measuring system so that it provides prescribed indications corresponding to given values of a quantity to be measured.

CALIBRATION SERVICES - SAFETY

As an ilac-MRA and iAS accredited laboratory, UL's Carugate Calibration Centre is equipped to conduct calibration activities in our facility or on-site in our customers' labs.

Available services include calibration, verification, adjustment and labeling. To ensure conveniences, all of our calibration services are modular, meaning you can request the complete metrological confirmation process or only a part of the confirmation process. Every complete process includes the evaluation of instrument conformity to the standard under which it will be governed. Further, our calibration experts provide advice for managing "out of specification/tolerance" measurement instruments.

Metrological Confirmation



The Carugate Calibration Centre can calibrate commercial and/or custom instrumentation, in a variety of quantities, in the following categories:

- **Electrical:** DMM, Power Meter, Voltage and Current Harmonics, Leakage Current Meter and Network, Current Clamp, Built-in Meter, Components
- **Thermal:** Temperature Data Logger, Thermocouple, Climatic Chamber, Climatic Environmental Unit
- **Dimensional:** Caliper, Micrometer, Tape Measure, Test Probe
- **EMC:** RF cable, Directional Coupler, ISN, LISN, Attenuator, EM Clamp, RF amplifiers, Van Veen Loop antenna, Helmholtz Coil, CDN, Burst/Surge/Ring Wave generator, Harmonics & Interharmonics analyzer and Generators, Flicker
- **Others:** Fluid Pressure Meter/Transducers, Force Meter, Torque Meter, Scale, Mass

Metrological Confirmation of equipment subjected to calibration as verification of compliance to international regulatory requirements and/or to specific standards for which the instrument is used.

Calibration allows you:

- To provide traceability to the Internation System of Units (SI).
- To comply with ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories
- To comply with UL's Data Acceptance Program for simplified UL Certification
- To ensure compliance of products on the basis of traceable measurements, as required by the IECEE rules and the CE Mark
- To ensure the reproducibility of the measurements during the development of standards and/or products

Leakage Current Measurement

Five steps for a proper calibration process

The UL Calibration Centre is equipped to provide thorough support/training and calibration for leakage current equipment according to the following process:

STEP 1 — **Adequate Equipment**

Equipment components:
- Leakage network (fig. 3, 4, 5) according IEC 60990
- Voltmeter (DMM) or oscilloscope with adequate range frequency
- Swithces module with adequate rated value

STEP 2

Adequate calibration request:
- Full frequency range of the complete measurement system
- Correct range where the equipment will be used

STEP 3 — **Adequate Calibration Report /Certificate**

Initial Calibration (according IEC 60990):
- Input Impedance between 20Hz to 1MHz
- Transfer impedance or network response
- Annual Confirmation (according IEC 60990):
- Calibration of the dc input reststance
- Input and output voltage (or mA as indicated on the meter) between 20Hz to 1MHz

STEP 4

Adequate verification of the calibration report/certificate:
- Reference equipment and their uncertainty (range or reading related, in particulat for very low ranges)
- Adequate calibration method
- Compliance with the standards (IEC 60990 and product standard)

STEP 5 — **Metrological Confirmation**

Adequate Metrological Confirmation before to put the equiment in service:
- Compliance with the equipment specification (to be verified if in compliance with CTL decision or product standards) or
- Compliance with CTL decision or product standards
- Compliance with the max mueasing uncertainty decladed by the LAB

WHY THE PROCESS IS CRITICAL

Many calibration centres are not familiar with product standards and IEC60990 requirements, leading to end-line instruments experiencing the following deficiencies:

- Leakage current network not calibrated up to 1MHz
- Internal voltmeter or DMM with frequency range less than 1MHz
- Calibration method limited to 50/60Hz
- Input and transfer impedance not verified

Leakage Current Tester Calibration

Accredited calibration services

AC Leakage Current tester Simpson 229-2: Typical equipment used for Leakage Current measurement according UL Standards

Equipment requirements:

a) An input impedance of 1500Ω resistive shunted by a capacitance of 0.15µF

b) Indicate 1.11 times the average of the full-wave rectified composite waveform of the voltage across the resistor or current through the resistor

c) Over a frequency range of 0 – 100kHz, the measurement circuitry is to have a frequency response (the ratio of indicated to actual value of current) equal to the ratio of the impedance of a 1500Ω resistor shunted by a 0.15µF capacitor to 1500Ω

Calibration requirements:

a) At an indication of 0.5mA, the margin or error can not exceed 5% at 60Hz

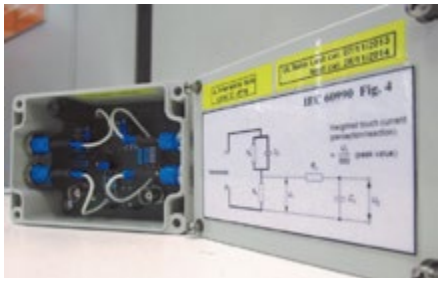
b) Frequency response

c) FormFactor


CALIBRATION
SERVICESSAFETY
70

Touch Current Circuits

Assembly/selling of dedicated leakage current measurement hardware



60990 Figure 4 Circuit with two current range: 20mA and 100mA

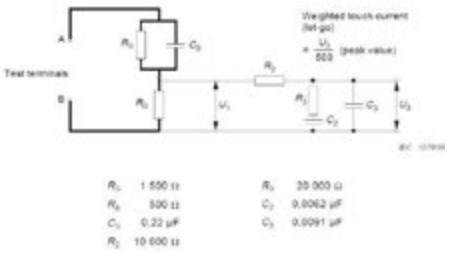


Figure 4: Measuring network, weighted touch current (perception/reach)

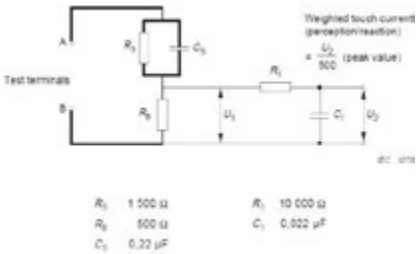


Figure 5: Measuring network, weighted touch current (let-go)

Initial Calibration Services

- Two different current range: 20mA and 100mA
- Selection of ideal components
- Adjustment of each branch of the circuit based on the calibration of the transfer impedance 20Hz-1MHz
- Proper tolerance in the complete range: 20Hz-1MHz

Subsequent Calibration Services

To ensure that your equipment continues to perform properly, regular calibration is required. Following initial calibration, your equipment will be calibrated according to the following criteria.

BENEFITS

- Meets the accuracy requirements of IECEE OD-5014 up to 100kHz
- The flexibility of In process adjustments as needed

APPLICABLE STANDARDS

- IEC 60990, 60335-1, 60950, 60065, 62109, 60598, 61347-1, 61558-1, 60730, 61010

Leakage (Touch) current (CTL OP 251)

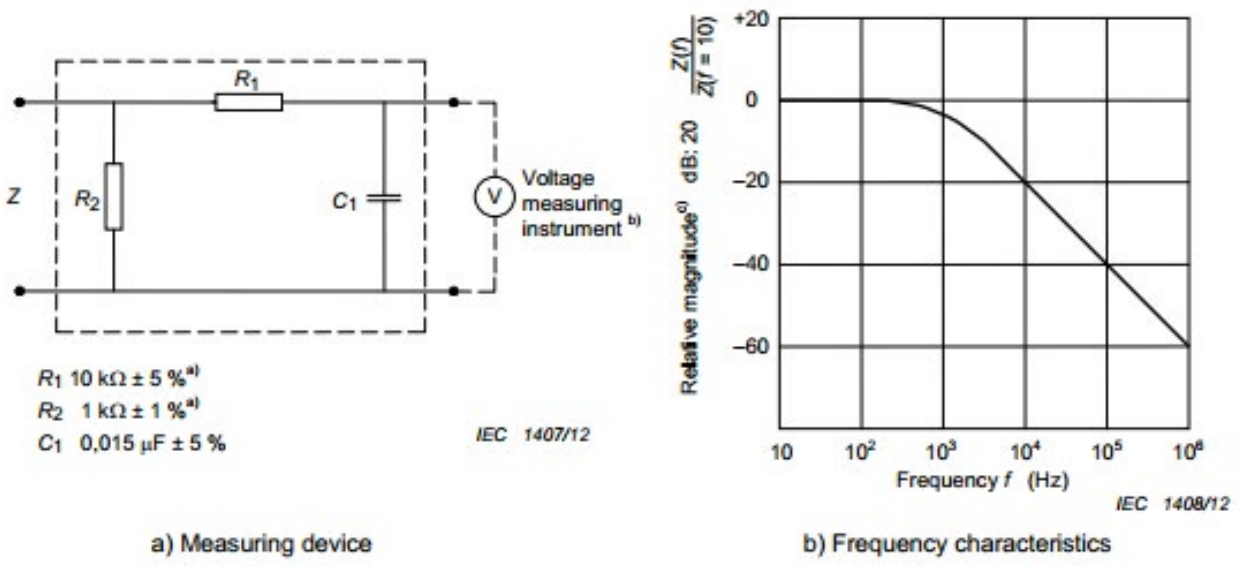
Up to 30mA	50Hz up to 60Hz	±3,5%
	>60Hz up to 5kHz	±5%
	>5kHz up to 1Mz	±30%

						TRANSFER IMPEDANCE						LEAKAGE CURRENT		
								Ref	ULRSS			S447 + AT118	CTL251C	
Frequency (Hz)		Measured value	S447 Vout	Vout/ Vin		Calculated value	Error	Uncertainty	Value	Acceptance	Result	UINSTR	Acceptance	Result
Hz	ohm	ohm	V				%rdg	%rdg	%rdg	%rdg	OK/ NOK	%rdg	%rdg	OK/ NOK
60	1986	1984,02	0,75245	0,251	498	497,625	0,1	1,2	1,2	2,5	OK	2,8	3,5	OK
5000	512	511,82	0,399320	0,133	68,3	68,127	0,3	1,2	1,2	2,5	OK	2,8	3,5	OK
1000000	476	474,77	0,00353	0,001	0,345	0,335	2,9	1,6	3,7	20,0	OK	20,0	30,0	OK

Touch Current Circuit for Medical Standards

Assembly/selling of dedicated touch current measurement hardware

IEC 60601-1 Figure 12: Example of a measuring device and its frequency characteristics



a) Measuring device

b) Frequency characteristics

Allowable values apply to currents flowing through the network of (IEC 60601-1 Figure 12 a) and measured as shown or by a device measuring the frequency contents of the currents (see IEC 60601-1 Figure 12 b). The values apply to d.c. and a.c. and composite waveforms. Unless stated otherwise, they may be d.c. or r.m.s.

APPLICABLE STANDARDS

- IEC 60601-1

The allowable values of the patient leakage currents and patient auxiliary currents are stated in Table 3 and Table 4. The values of a.c. apply to currents having a frequency not less than 0,1 Hz.

CALIBRATION SERVICES**SAFETY**

Conformity Evaluation

Laboratory testing of energy efficiency for three-phase Induction motors

On-site services include:

- Analysis of all calibration certificates associated with equipment used for testing
- Issuance of Accredited Calibration Certificates, as needed
- Evaluation of measurement uncertainty of all equipment used for testing from external accredited calibration certificate
- Issue a conformity report to perform testing of three-phase induction motor as prescribed by the standard

APPLICABLE STANDARDS

- CSA C390-10

Quantities involved in the analysis:

- Voltage
- Current
- Active power
- Torque
- Speed RPM
- Temperature
- Winding resistance

Climatic Chamber Oven Services

On-site calibration and verification of climatic chambers/ovens

UL's accredited calibration is performed for temperature and humidity and includes measurement at the center and 9-15 additional area measurement points depending on chamber dimensions. Calibration results are compared with the requirements of different standards and/or customer specifications. A certificate is issued when calibration is complete.

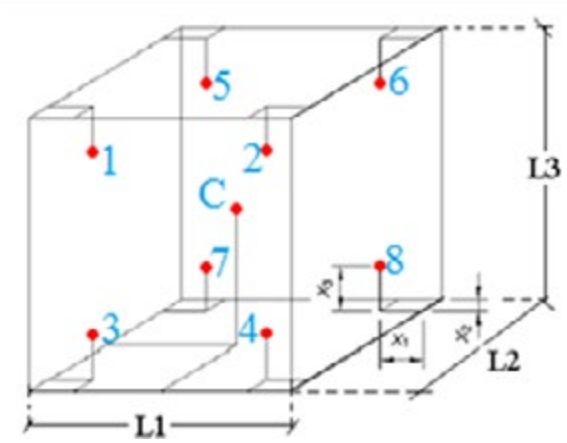


Figure 1: Measurement setup with 9 points for a climatic chamber up to 2000 ft.

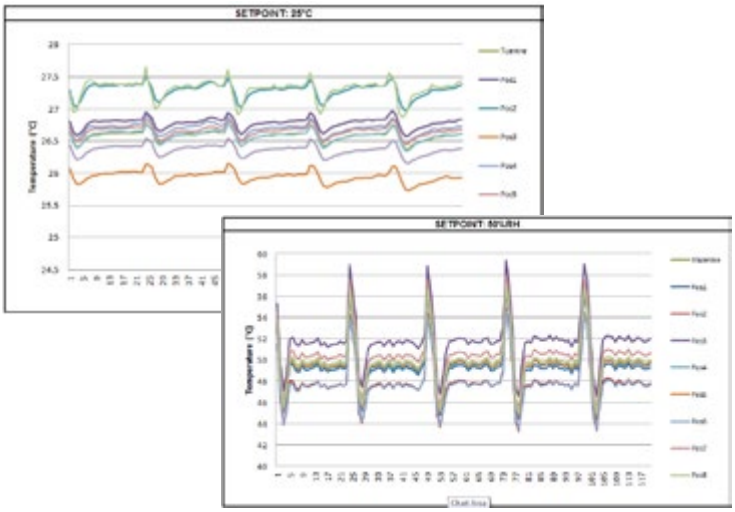


Figure 2: Example data, calibration of uniformity of temperature and humidity

The Carugate Calibration Centre can also perform performance verification of a climatic chamber/oven from rise and fall ramp verification to air speed inside, complete with a verification report.

APPLICABLE STANDARDS

- IEC 60068-3-5
- IEC 60068-3-6
- IEC 60068-3-11

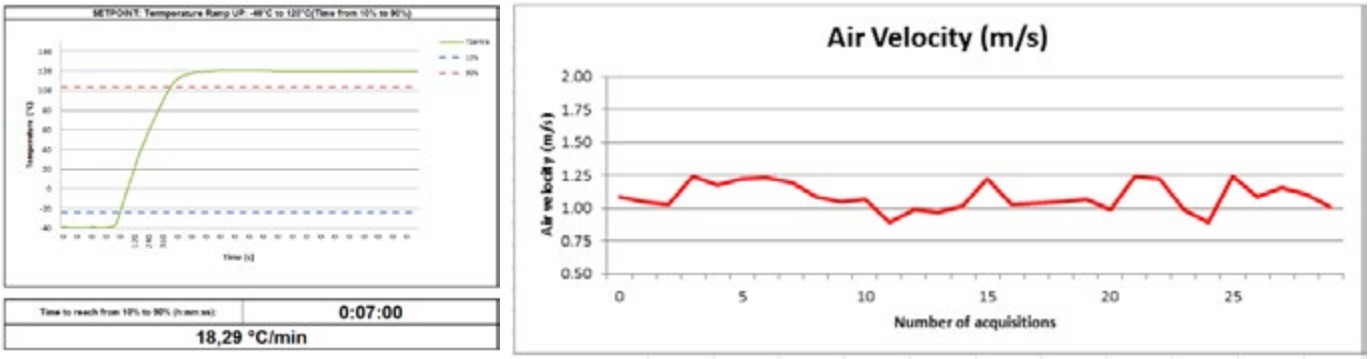


Figure 3: Verification of rise ramp and air velocity of chamber


CALIBRATION
SERVICESSAFETY
2MHz
V
mV

Compliance Verification

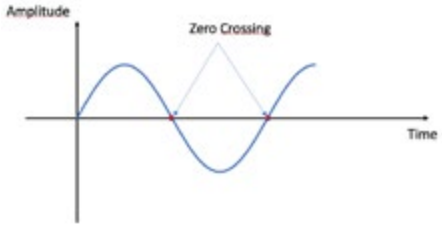
Harmonic analyzer verification according to IEC61000-4-7 (PLL, Grouping, LP)

Many power quality analyzers on the market can measure voltage and/or current harmonics. However, not all of these instruments use the criteria required by the power quality or emission EMC standards.

UL's Calibration Centre performs accredited calibration according to the applicable standards and validates the correct implementation of the following three algorithms:

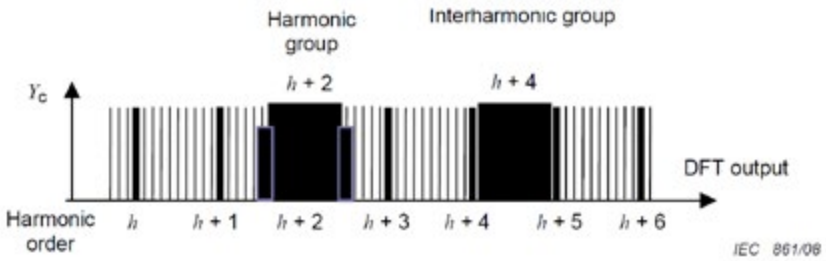
Phase-Locked Loop (PLL)

PLL function (SW or HW) allows for the synchronization of the time window (200ms– 10 whole cycles) with the sampling frequency to have the first and the last acquired samples equal to zero (known as zero crossing).



PLL function enables the avoidance of adjacent inter-harmonics that compromise the measurement.

GROUPING



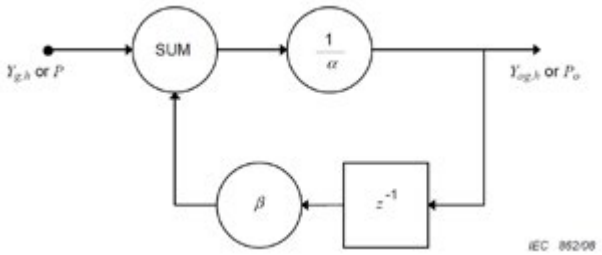
Grouping allows for the consideration of all inter-harmonics in the harmonics measurement.

Each harmonics accounts for 4 inter-harmonics before and after and half of the fifth inter-harmonics after and before.

Grouping verifies the amplitude of the harmonics measured when the inter-harmonic source is the two adjacent and the inter-harmonic between two harmonics.

Low Pass Filter (LPF)

Harmonics and inter-harmonics must be low pass filtered with a digital filter as indicated in the figure at right.



WHY IS IEC 61000-4-7 IMPORTANT FOR POWER QUALITY?

- On public networks, distortion components may include inter-harmonics
- Switching loads (thermostats) generate inter-harmonics
- Non linear loads (switching, non symmetrical controls, etc.) generate inter-harmonics
- Signaling on public network is generally located between two adjacent harmonics
- Electronic motor drivers with varying torque generate 5th harmonic fluctuating, which in turn generates inter-harmonics

Voltage Inter harmonics & Harmonic Analyzers

On-site calibration of voltage harmonic analyzers used for power quality management according to UL Procedure 00-OP-C0036, CTL-OP110, IEC 61000-4-30

Our field engineers use UL developed harmonic and inter-harmonic software and hardware during calibration. Our voltage inter-harmonics meter (VIHM) is a 3-channel selective voltmeter able to measure RMS voltage values for maximum 40 harmonics/inter-harmonics sinusoidal signals overlapped to the main supply. This equipment is available for purchase or rental.

CURRENT HARMONICS - 20A Shunt 50Hz

Applied quantity			Equipment in calibration		Measurement Results	
Parameter	Value	Frequency	Range	Reading	Error	Uncertainty
Hrm 1	15,9993 A	50 Hz	20 A	16,0052 A	0,01 A	48,26 mA
Hrm 2	0,79698 A	100 Hz	20 A	0,7973 A	0,00 A	12,02 mA
Hrm 3	0,79694 A	150 Hz	20 A	0,8015 A	0,00 A	12,08 mA
Hrm 4	0,79732 A	200 Hz	20 A	0,7978 A	0,00 A	12,03 mA
Hrm 5	0,79706 A	250 Hz	20 A	0,7963 A	0,00 A	12,00 mA
Hrm 36	0,79684 A	1800 Hz	20 A	0,8072 A	0,01 A	12,17 mA
Hrm 37	0,79678 A	1850 Hz	20 A	0,8071 A	0,01 A	12,17 mA
Hrm 38	0,79686 A	1900 Hz	20 A	0,8084 A	0,01 A	12,19 mA
Hrm 39	0,79668 A	1950 Hz	20 A	0,8087 A	0,01 A	12,19 mA
Hrm 40	0,79655 A	2000 Hz	20 A	0,8075 A	0,01 A	12,17 mA

Example Report: THD (range 0.1 < 50%)

VOLTAGE THD% - *Equipment Settings:THD, Channel 1 - Fundamental: 120V@60Hz; THD: 1% (traceable, not accredited)*

Applied quantity			Equipment in calibration		Measurement Results	
Parameter	Value	Frequency	Range	Reading	Error	Uncertainty
Fund	119,9832 V	60 Hz	300 V	119,9959 V	0,0127 V	0,30 V
Hrm 5	0,97653 %fund	300 Hz	300 V	0,97655 %fund	0,0000 %fund	0,002 %fund
THD	0,9765 %		100 %	0,9766 %	0,000 %	0,002 %

Scope of Accreditation

CURRENT HARMONICS - interharmonics and THD meters

Measurement Area	Range & Resolution			Calibration & Measurement Capability[1] (CMC) (±)		Technique, Reference Standard, Equipment
	Par	IHRM Amplitude	IHRM Frequency	U1	U2	
AC Current Harmonics and Interharmonics - Measure	Fund	30V to 300V	50Hz/60Hz	5,0E-03 rel	58 µV/U	UL International Italia VIHM IEC 61000-4-7 (Note 1, 2, 12)
	IHRM11 to IHRM2000	0,3V to 60V	55Hz to 12kHz	1,0E-02 rel	58 µV/U	
	THDI	Fund: 30V to 300V	55Hz to 12kHz	4,0E-03 rel	58 µ%THD/THDV	

BENEFITS

- No equipment removal or disconnection required
- No risk of equipment damage during transportation
- Minimal interruption of client lab activities

APPLICABLE STANDARDS

- IEC61000-4-7

Equipment/Software Features

- Quick test setup and execution
- Collect, monitor, manage and export data

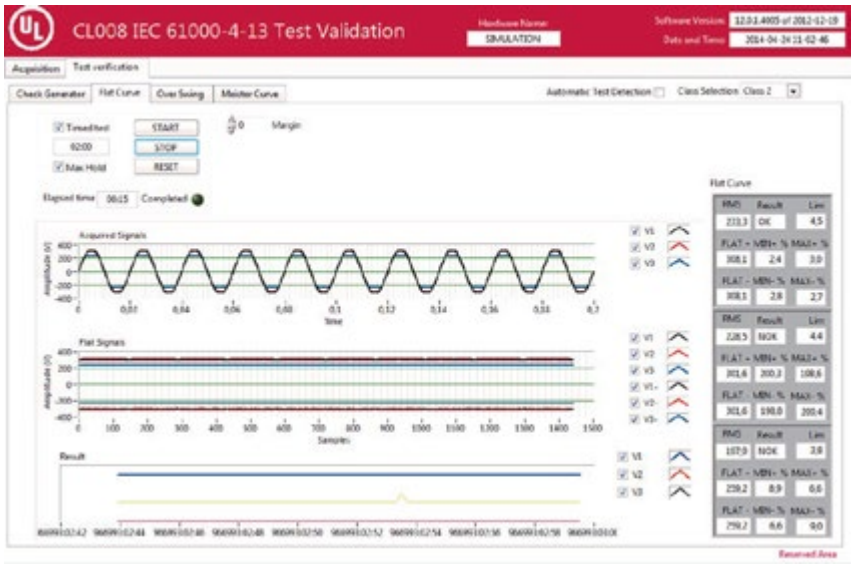
Equipment/Software Specifications

- 600 Vrms channel-to-channel insulation
- 50 kS/s/ch simultaneous input
- Built-in antialiasing filter
- 300 Vrms measurement range
- USB Connection

Power Quality Validation

On-site validation of clients' power quality

Our field engineers use UL developed power quality analyzer software and hardware during calibration. Our 3-channel power quality analyzer (3PQA) has a 300Vrms measurement range. This equipment is available for purchase or rental. Upon completion of the validation, a report detailing the measurement without load and at maximum load, including a graph of the voltage, frequency, and THD over an hour measurement period will be issued. A resistive load up to 32 A can be provided.



BENEFITS

- No annual dedicated equipment calibration
- Easy selection of measurement points
- Access to expert support for the correction of identified power quality issues.

APPLICABLE STANDARDS

- ISO/IEC 17025:2005, 5.3.2

Equipment/Software Features

- Quick test setup and execution
- Easy collection, monitoring, management and exporting of data
- Automatic report generation

Equipment/Software Specifications

- Main freq: 45-65Hz
- Inter-harmonics: up to 9kHz
- Connection mode: USB
- 600 Vrms channel-to-channel insulation
- 50 kS/s/ch simultaneous input
- Built-in antialiasing filter
- 300 Vrms measurement range

CALIBRATION SERVICES**SAFETY**

Complete Calibration and Validation Training

Full training services to educate your entire laboratory team

1. SELECTION AND MANAGEMENT OF EQUIPMENT FOR SAFETY TESTING

- Categories of equipment used in certification safety laboratories
- Critical equipment specification
- Selection guidelines related to:
  - Interconnectivity (connection to automatic data acquisition, network)
  - Standards requirements (values and range)
  - Product to test (Frequency range, etc)
  - Accuracy (according to standards and/or IECEE OD-5014 former CTL DSH251, reading or range accuracy)
  - Safety issues
  - Calibration intervals
- Ordinary maintenance (IEC17025) and maintenance procedures
- Selection analysis
- Management of equipment according to IEC17025: Overload, repair and calibration (periodic and before out of service)

2. CALIBRATION PROCEDURE FOR SAFETY TESTING

- General requirements for internal calibration (IEC17025)
- Content of calibration procedure
- Recognized calibration guidelines
- Validation of calibration method
- Validation of auxiliary equipment or setup
- Examples of the calibration procedure: temperature, active power, etc

3. CALIBRATION PROCEDURE FOR EMC AND IMMUNITY TESTING

- Calibration procedure for emission
- Validation of auxiliary equipment or setup
- Examples of the calibration procedure: RF Amplifiers, Harmonics and Flickers, etc

4. TOUCH CURRENT TEST METHOD AND SETUP

- Requirements according IEC 60990
- Measurement methods for touch current and protective conductor current
- Body effect
- Annex B: use of the conductive plane
- Figures 3, 4, and 5 of IEC60990
- Setup and Calibration Issues

5. INTERACTION WITH A CALIBRATION CENTRE

- Calibration requests according to equipment usage
- Correct range, offset, and number of calibration points
- Request for accuracy verification (metrological confirmation according to equipment specification)
- Management of adjustment, out of tolerance report
- Acceptance of the calibration certificate/report
- Selection of the critical parameters for drift analysis (calibration interval)
- Common calibration centre mistakes (reports, calibration methods, standard procedures)

6. CALIBRATION AND MEASUREMENT UNCERTAINTY FOR SAFETY TESTING

- Type A and Type B uncertainties
- Basic statistical elements: Mean, standard deviation, distribution, etc
- General contributors to measurement uncertainty and the source of uncertainty
- Direct and derived measurement
- Quantities statistically independent or correlated
- Declaration of measurement uncertainty (repeatability and reproducibility)
- Examples of measurement uncertainty calculation for direct measure (active power) and derived measurement (temperature of winding)

7. METROLOGICAL CONFIRMATION FOR SAFETY TESTING

- Basic definitions
- Standard requirements concerning accuracy
- IECEE OD-5014 : range or reading accuracy
- Impact of the range or reading accuracy
- Definition of internal measurement uncertainty

8. METROLOGICAL CONFIRMATION FOR EMC TESTING

- Basic definitions
- Standard requirements concerning accuracy
- IECEE OD-5014 : range or reading accuracy
- Impact of the range or reading accuracy
- Definition of internal measurement uncertainty

9. MODULATION OF CALIBRATION INTERVAL

- Reference standards
- Manufacturer suggestion (specification)
- Evidence of stability in critical parameters
- Risks of traceback

10. SAFETY RULES FOR EQUIPMENT USED IN SAFETY TESTING

- Technical documentation related to equipment
- Specification, maintenance and safety sections
- Differences between danger and risk
- Equipment classification based on risk
- Specific risks connected to mechanical, electrical and thermal equipment

11. POWER QUALITY FOR TESTING LABORATORY

- IEC17025 requirements
- Selection of the measurement points
- Equipment and accuracy
- Algorithm to calculate harmonics and inter-harmonics (2-9kHz)
- Voltage and current harmonics
- Equipment available on the market
- Measurement issues with equipment that is not IEC61000-4-7 compliant
- Calibration certificates issued by UL Carugate Calibration Centre
- Measurement uncertainty

12. ISO/IEC 17025

- 5.2 Personnel: Training, qualification, maintenance
- 5.3 Laboratory Accommodation & Environment Conditions
- 5.4.7 Uncertainty of Measurement
- 5.5 Measurement & Test Equipment: suitability and management
- 5.6 Traceability of Measurements: Calibration
- 5.9 Assuring Quality of Test Results

About the Carugate Laboratory

UL's Carugate Laboratory, established in 1984 as a private company, has been part of the UL family since 2003. The lab covers approximately 1700 square meters spread over two buildings. A large team of on-site engineers and technicians is dedicated to various different sectors: electrical safety, electromagnetic compatibility, performance, metrological confirmation (calibration) services and automation services.

The Carugate Lab has been operating for about 30 years in the electrical sector. We are currently accredited to IECEE, ACCREDIA, OSHA, IAS and more.

THIS LOCATION PROVIDES TESTING AND CERTIFICATION SERVICES IN THE FOLLOWING AREAS:

INTERNATIONAL MARKET ACCESS Thanks to the above mentioned accreditations, this laboratory is able to issue test reports and certificates under the IECEE CB scheme (HOUS and CONT) and ILAC-ACCREDIA reports recognized within the European Accreditation and worldwide.

INVERTER: Thanks to more than 10 years of experience and continuous updating of the scope of accreditations, Carugate Laboratory is now able to test and certify high power photovoltaic inverters, wind inverters and other types of inverters in accordance with low Voltage and EMC European Directives. We can also carry out these tests at customers' premises. The lab is also specialized and accredited for the tests required by several countries in Europe, Asia and Australia according to international, European and local standards and rules.

EMC: Testing for the following areas: household appliances, lighting, medical and hi-tech equipment, laboratory instrumentation, ISM (industrial, scientific and medical) and standards for commercial and industrial environments with the possibility of issuing CE reports, CB reports under the IECEE scheme (EMC) and ILAC - ACCREDIA reports recognized within the European Accreditation.

PERFORMANCE AND SPECIAL TESTS: measurement of human exposure to vibration (hand/arm or whole body transmitted) and special tests (thermal, acoustic, EMC, dimensional, safety, etc.); custom specifications required by clients.

TESTS ACCORDING TO UL STANDARDS: to obtain UL and cUL mark (USA and Canada) for most product categories. For more detail see the Laboratory Capabilities Catalog and the Laboratory Services Catalog

CALIBRATION SERVICES: along with standard calibration offerings, UL Italy Calibration Center can assist you with calibration services tailored to your specific needs.

AUTOMATION SERVICES: Project management, design, fabrication, programming, installation, projects start-up, operating support.

Information on our accredited calibration services for safety/EMC laboratories can be found in "UL Calibration Services: Accredited Calibration for EMC Laboratories"

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