REPORT OF THE RESEARCH AND DEVELOPMENT ACTIVITIES OF INMETRO ELECTRICAL METROLOGY DIVISION (2019-2021)

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Scope

This report presents the recent research activities in electricity and magnetism performed at Inmetro to support the confidence-building mentioned in the CIPM Mutual Recognition Arrangement (CIPM MRA).

Research and Development

(a) Voltage

- Dissemination of the ac voltage unit from near dc to 1 kHz with reduced uncertainties (typically less than 1 μV/V) using the Programmable Josephson Voltage System (PJVS) and digital sampling techniques. The system will be also used to ensure the traceability for ac power and energy measurements and to characterize thermal converters at low frequencies with reduced uncertainties.
- A thermal converter with frequency output is under development for ac-dc voltage transfer measurements.

(b) Current

- Modelling of the phase displacement of cage-type current shunts for nominal currents from 0.5 A to 20 A is under development. A lumped equivalent circuit model for current shunts assembled according to this design was conceived. The phase displacement of shunts with nominal currents from 0.5 A to 20 A are computed using standard two-port network theory. The model will help on future design decisions.
- A measuring system based on the charging and discharging times of reference capacitors is under development to measure dc currents from 1 fA to 10 μA.

(c) Resistance

- Several actions have been implemented to provide international recognition for our dc quantum Hall system. See below Inmetro´s participation in comparisons run by BIPM.
- A measuring system based on the modified Wheatstone bridge is under development to measure dc resistance from 1 GΩ to 100 TΩ.

(d) Impedance

- Traceability chain to derive the capacitance unit from the dc quantum Hall effect. The calculable resistor, the quadrature bridge, and the inductive voltage divider calibration system based on the bootstrap method are under development.
- An accurate system for measuring impedances at frequencies up to 300 kHz is under development. The system comprises a digital bridge to compare impedances both in-phase and in quadrature, high-stability digital signal synthesizers, analog-to-digital converter with control software, and auxiliary circuits.

(e) Power

- A PMU calibration system is under development to provide traceability to our recently purchased Fluke 6135A PMU calibration system.
- Development of a measuring system for electrical disturbances related to power quality.

(f) High voltage

- Traceability of ac high voltage (HV) measurements to low voltage (LV) measurements. The methodology adopted aims at characterizing a reference HV potential transformer with a HV capacitance bridge and HV and LV standard capacitors. The values of capacitance and dissipation factor of the standard capacitors need to be known by the time of the reference potential transformer characterization. The voltage coefficients will need to be estimated and the overall uncertainty evaluated.
- Traceability of dc HV measurements to LV measurements based on the 'binary step-up' procedure is under development.
- Extension of the ac HV range to 500 kV and implementation of a system for measuring impulsive voltages are under development.
- Traceability of ac HV measurements at harmonic frequencies (initially from 50 Hz to 2 kHz) is under development.

(g) High current

- Traceability of ac high current measurements based on model-based calibration is under development. Two standard current transformers (CT) are compared with the reference bridge and several parameters of the two CT are measured to conceive the theoretical model for the CTs. The model is validated and employed to calibrate the reference bridge. Both single- and double-stage CTs will be evaluated.

(h) Magnetic field

- Improvement of the magnetic field metrology with the acquisition of new equipment.
- Implementation of field measurements of static and alternating magnetic fields (at network frequencies) according to Brazilian standards.

Regional Project

- Regional project among Inmetro (Brazil), INTI (Argentina) and UTE (Uruguay), funded by the Brazilian government, to build a reference system for measuring electric power up to 100 kHz. Inmetro is coordination this project. Inmetro constructed one stable 24 A transconductance amplifier. Three 12 A transconductance amplifiers and three power amplifiers with output up to 240 V @ 100 mA still need to be constructed. INTI constructed one digitizer and one signal generator and is testing them now. Two additional digitizers and two additional signal generators still need to be constructed. The modules constructed will be distributed among the participating NMIs so that a reference measuring system can be integrated in each country.

International Comparisons

- Inmetro is participating in the BIPM key comparison of resistance standards (BIPM.EM.K13.a) as a preliminary step for participation in the BIPM key-comparison of quantum Hall resistance standards and their scaling to other resistance values (BIPM.EM.K12).
- Inmetro is participating in the CCEM key comparison of ac-dc voltage transfer standards (CCEM-K6a/K9).
- Inmetro is participating in the CCEM key comparison of electric power (CCEM-K5).
- Inmetro is participating in the regional supplementary comparison of voltage, current and resistance measurement (SIM.EM.S13).

Publications

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- SOUZA L. A., BARROS E VASCONCELLOS R., LIMA A. C. and VITORIO P. C., "Metrological characterization of a wideband RVD prototype by impedance bridge measurements with rational approximation in the frequency domain," *XIII SEMETRO Congress Digest – International Congress on Electrical Metrology*, Florianopolis, Nov. 24-27, 2019.
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- LANDIM R. P., CARVALHO H. R. and OLIVEIRA V. C., "The redefined SI and the electromagnetic quantities in detail – I," *XIII SEMETRO Congress Digest – International Congress on Electrical Metrology*, Florianopolis, Nov. 24-27, 2019.
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