EMPIR Call 2017 – Industry, Fundamental, Normative and Research Potential

Selected Research Topic number: **SRT-r01**
Version: 1.0

Title: Versatile electrical impedance calibration laboratory based on digital impedance bridges

Abstract

The need for traceable measurement of electrical impedance is acknowledged across industry sectors, for example in sensor technology and the characterisation of materials. Only a fraction of NMIs can sustain a primary impedance laboratory, as traditional impedance bridges are expensive to build, maintain and operate.

This topic focuses on the development of a new impedance metrology infrastructure, accessible to all NMIs, based on the novel concept of digital impedance bridges. The developed capabilities will enable NMIs to provide a primary-level electrical impedance calibration service for European industry, without requiring the use of traditional impedance bridges.

Keywords

Impedance metrology; digital impedance bridges; calibration; CMC; electrical units; capacitance; inductance

Background to the Metrological Challenges

Electrical impedance measurements are ubiquitous in the manufacturing and characterisation of electrical and electronic devices, and in the design, manufacturing and testing of electronic circuits. For example, several types of sensors (resistance thermometers, capacitive displacement sensors, proximity sensors (including touch screens), barometers and hygrometers) convert the non-electrical quantity of interest into an electrical impedance output. Electrical impedance spectroscopy also plays a very strong role in non-destructive testing for a wide array of analyses, such as chemical and biological characterisation of solids, liquids and biological materials, and measurement of the electrical properties of materials (permittivity, permeability, dielectric loss) is based on accurate impedance measurement of a fixture or cell.

Metrological traceability of the impedance measurements is a prerequisite for the reliability and comparability of the results of such analyses. Traceable impedance measurements require calibrated instruments. The calibration verifies the performance of the meter over a section of the complex plane using secondary artefact resistance, capacitance and inductance standards, covering several decades of magnitude and frequency. The calibration of these standards constitutes the core output of electrical impedance metrology laboratories in National Metrology Institutes.

Setting up a “traditional” laboratory for primary impedance metrology involves the acquisition of a set of different specialised impedance bridges not available on the market and which, therefore, have to be purpose-built including the construction of specialised electromechanical parts. Traditional bridges are manually operated and require highly skilled operators. The effort, manpower and budget required for a traditional impedance laboratory is therefore not accessible to small or less-experienced NMIs.

The newly available technology of digital impedance bridges, developed in the framework of recent joint research projects by NMIs working in the field of impedance metrology (in particular SIB53 AimQuTE), has shown a potential to overcome the present barrier to development. Collaborative research is required to effectively exploit the newly developed technology and enable NMIs to realise SI impedance units and scales at a reduced cost, and thus provide new primary-level electrical impedance calibration services for industry and calibration centres.

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Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on the development of metrological capacity in electrical impedance.

The specific objectives are

1. To review the developments in digital impedance bridges in previous research projects, including e.g. EMRP SIB53 AimQuTE, and to determine the most suitable approach(es) to be adopted in this project based on industrial and stakeholder needs.
2. To realise inductance scales in the range 1 mH – 10 H, with uncertainties in the 10^{-5} range, and a capacitance scale in the range 1 nF – 10 uF, at frequencies in the range 120 Hz - 1592 Hz, with uncertainties in the 10^{-6} range, suitable for primary dissemination towards industry and calibration centres.
3. To validate the new inductance and capacitance scales.
4. To develop new and/or improved draft Calibration and Measurement Capabilities (CMCs) in the context of the CIPM Mutual Recognition Arrangement for the new inductance and capacitance capabilities.
5. For each participant, to develop an individual strategy for the long-term operation of the capacity developed, including regulatory support, research collaborations, quality schemes, and accreditation. They should also develop a strategy for offering calibration services from the established facilities to their own country and neighbouring countries. The individual strategies should be discussed within the consortium and with other EURAMET NMIs/DIs, to ensure that a coordinated and optimised approach to the development of traceability in this field is developed for Europe as a whole.

Joint Research Proposals submitted against this SRT should identify

- the particular metrology needs of stakeholders in the region,
- the research capabilities that should be developed (as clear technical objectives),
- the impact this will have on the industrial competiveness and societal needs of the region,
- how the research capability will be sustained and further developed after the project ends.

The development of the research potential should be to a level that would enable participation in other TPs.

Proposers should note that the programme funds the activity of researchers to develop the capability, not the required infrastructure and capital equipment, which must be provided from other sources.

EURAMET has defined an upper limit of 500 k€ for the EU Contribution to any project in this TP, and a minimum of 100 k€.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 10 % of the total EU Contribution to the project.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Provide a lasting improvement in the European metrological capability and infrastructure beyond the lifetime of the project,
- Facilitate improved industrial capability or improved quality of life for European citizens in terms of personal health or protection of the environment,
- Transfer knowledge to the electrical, electronics and energy sectors and the metrology community.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] Joint Research Project EMRP 2012 SIB53 AimQuTE, *Automated impedance metrology extending the quantum toolbox for electricity*, http://www.ptb.de/emrp/aimqute.html