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

Selected Research Topic number: **SRT-r02**
Version: 1.0

Title: A digital traceability chain for AC voltage and current

Abstract

Dynamic electrical measurements are critical in many applications where the RMS (root mean square) value of an electrical signal does not provide the required information and the signal needs to be sampled and processed. At present, NMIs and calibration laboratories provide traceability with high accuracy using thermal converters, but this is limited to AC magnitudes deduced from RMS values. As a consequence, the most accurate commercial calibration equipment is also limited to RMS values. Several research projects have developed AC quantum standards to provide traceability for dynamic measurements within some European NMIs. It is now necessary to establish the traceability chain for dynamic electrical measurements to a wider group of NMIs and calibration laboratories.

Keywords

Digital metrology, analogue to digital converter, Josephson standard, RMS, thermal converter, AC quantum standards

Background to the Metrological Challenges

AC voltage and current measurements have been related to corresponding DC values using transfer techniques mainly based on thermal converters for more than 60 years. This technique is not only in use at NMIs but also at the high-level calibration laboratories. Thermal converters are able to provide the necessary accuracy, at the 10^{-6} level and for some specific voltages and frequencies even to the sub-10^{-6} level. Although their accuracy is good, they are limited to providing RMS values in the presence of stationary sine waves and sinusoidal waveforms with low harmonic content. This leads to a traceability limitation for dynamic electrical measurements, critical in many applications, where the RMS value of the electrical signal does not provide the required information and the signal needs to be sampled and processed.

Substitution methods already developed in comparison experiments between AC quantum standards and digital electrical instruments using thermal converters are not suitable in the presence of dynamic signals and suffer from the low input impedance of thermal converters, which in some cases may not be compliant with the maximum current supplied from the AC quantum voltage source. It is therefore necessary to establish this traceability chain, from SI quantum units to the digital dynamic electrical measurement equipment, in a clear way that can be followed by NMIs, calibration and testing laboratories, and industry.

During the last two decades, much work has been carried out in AC quantum voltage standards based on the Josephson Effect to both provide traceability to dynamic measurements and play a key role in the redefinition of the SI electrical units. Several European NMIs have participated in a number of projects related to AC quantum voltage research. The iMERA-Plus JRP T4.J03 JoSy started the European funded joint research on AC quantum voltage and made first prototype systems available. This was followed by the EMRP JRP SIB59 Q-WAVE, which focused on providing traceability for precision analogue to digital converters, and the on-going EMPIR JRP SIB04 QuADC that will deliver results from DC to MHz frequencies ready for wide scale adoption across the NMI community. The AC quantum voltage infrastructure and knowledge developed in the framework of European research projects are not yet accessible in a form for implementation in a wider group of NMIs with less developed capability and high-level calibration laboratories. The objective of the on-going EMPIR JRP 14RPT01 ACQ-PRO is to reduce the technological gap between European NMIs in AC quantum voltage. This project has also demonstrated how the community can work together to realise research potential across many NMIs in Europe using a common technological platform.

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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 for the transition from analogue to digital measurements for AC voltage and current.

The specific objectives are

1. To define the sensor requirements and metrological grade electrical parameters for digital electrical measurements for AC voltage and current, including identifying the traceability and performance related to the requirements of using AC quantum voltage standards.
2. To develop measurement systems (comparators) employing digital techniques for use at NMIs and calibration laboratories to achieve a practical realisation of step-up and step-down procedures (scaling) for electrical current and voltage, beginning with a Josephson standard as the fundamental reference.
3. To develop publicly available methods, algorithms and software for the traceability chain of dynamic measurements, including fast data processing and uncertainty estimation, for use by NMIs and calibration laboratories. The methods should facilitate the quick integration of future improvements.
4. To validate the complete system: comparator, passive coaxial current and voltage devices, algorithms, and software. This should facilitate the approval of new calibration and measurement capabilities for dynamic measurements.
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 sector 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.