EMPIR Call 2014 – Industry and Research Potential

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

Title: Towards the propagation of ac quantum voltage standards

Abstract

The application of the Josephson effect, as the basis of a DC voltage reference, started 30 years ago. Today many NMIs in Europe and worldwide possess such a quantum standard. More recently research has been undertaken to develop a quantum ac voltage reference based on the same effect. These types of standards will refer the magnitudes of the ac electrical parameters directly to the fundamental constants that will define the future SI. Different approaches have been used to reach this goal, however the systems are complicated to construct and operate and as a consequence only a few NMIs in Europe have the capability to conduct research on these standards. There is therefore a need to develop less complex versions of these standards that are more practical to operate.

This topic is focused on improving the availability of practical ac quantum voltage standards and research capability at NMIs/DIs within countries or regions in Europe where access to these types of facilities is currently limited.

Keywords

Practical ac quantum voltage standard, ac waveform metrology, Josephson effect, Josephson Arbitrary Waveform Synthesizer (JAWS), Programmable Josephson Voltage Standard (PJVs), capacity building

Background to the Metrological Challenges

Over the last decade there has been a substantial research activity on ac waveform metrology based on Josephson effect, aimed at the development of ac quantum standards. This research is expected to continue for several years, extending and improving the standards already established and developing new applications. The established ac voltage standards, which are based on thermal converters, relate the ac value to the dc value by the heat dissipated in a resistive element. Their main limitation is that they only provide the RMS values whereas digital instrumentation requires traceability for sampled measurements with complex amplitude and phase information. In addition to the improvement in ac measurement capabilities, quantum effects play a fundamental role in the redefinition of the SI electrical units, allowing their direct realisation. The related technology is currently only available for a few European NMIs.

An NMI or DI wishing to establish a research capacity in this area would do so through the design and upgrade of the existing quantum standard infrastructure or by establishing a new practical ac quantum voltage infrastructure, and through the validation of the performance of the new infrastructure. The design would build on the experience of the more developed NMIs which have already developed this capability, using their expertise to optimise the design based on the available quantum standard infrastructure and required performance for the particular needs of that country. The validation process would involve the NMI establishing the capability participating in comparisons and analysis of uncertainties with others establishing similar facilities and those with already established facilities. The whole process would result in both the development of a facility, the development of the relevant staff and the development of relationships between the establishing NMI and more experienced researchers in the field which would foster further joint research activities beyond the life of the project.

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 proposal.

The JRP shall focus on the development of metrological capacity in ac quantum voltage metrology.

The specific objectives are

1. To design a new practical ac quantum voltage infrastructure accessible to all NMIs, which is easier to implement and operate, maintaining the potential research capacity. The design should be for a consolidated quantum voltage standard based on the knowledge acquired in previous research projects, where different types of approaches were followed.
2. To transfer experience and expertise in different and specific technologies to enable the integration, operation and modification of ac voltage quantum standards. Pioneering work carried out in European NMIs over the last few years in the field of ac quantum metrology should be shared with the less experienced NMIs (for example via workshops, tutorials, on-site training courses, visits). The purpose is not only to provide the infrastructure but also the capacity to improve the measurement technology through continuing research and development.
3. To develop and validate measurement methods and to produce a Best Practice Guide on the use of AC Quantum Standards. The purpose is to document the acquired knowledge in a rational way collecting the inputs from different institutes and systems.
4. To establish the basis for future cooperation among European NMIs related to quantum voltage standards research and the further propagation of their use (working group, web pages, training courses).
5. For each emerging NMI participant to develop an individual strategy for the long-term development of their research capability in ac quantum voltage metrology including priorities for collaborations with the research community in their country, the establishment of appropriate quality schemes and accreditation (e.g. participation in key comparisons, the entry of CMCs into the BIPM database, accreditation to ISO/IEC 17025). 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.

Proposers shall give priority to work that meets documented metrological needs and activities that will lead to an improvement in European metrological capability and infrastructure beyond the lifetime of the project.

Proposers should establish the relevant current capability for research, and explain how their proposed project will develop capability beyond this.

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. Any deviation from this must be justified.

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 digital instrumentation 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”.

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.