EMPIR Call 2019 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-r04**
Version: 1.0

Title: Quantum traceability for AC power standards

Abstract

Power plays a crucial role in the metrology of electrical quantities. Therefore, over the last decade there has been a substantial interest on AC quantum standards, as well as on power and power quality (PQ) measurements. However, recent advances on transmission and distribution grids have led to an increasing demand for lower uncertainties in the measurement of power, power quality and phasor. Proposers addressing this SRT should address this by developing a quantum sampling standard, based on a Programmable Josephson Voltage Standard (PJVS) for electrical power, PQ and phasor.

Keywords

Electrical power, Power quality, Quantum traceability, Programmable Josephson voltage standard (PJVS), phasor

Background to the Metrological Challenges

NMIs typically trace electrical power measurement to the fundamental constants using a long chain of measurements, which leads to high uncertainties. However, a simpler and more direct traceability chain, building on a practical quantum sampling electrical power standard based on PJVSs - practical AC quantum voltage standards - can lead to lower uncertainties.

The first standard for electrical power based on the PJVSs was developed over a decade ago. It is based on the sampling of the voltage and current while digitizers are governed by the PJVS. Thus, the quantum power standard benefits from the unique stability of the PJVS. The uncertainties of electrical power measurements in institutes using PJVSs range from 5 to 25 µW/VA. Although PJVSs are commercially available, a quantum power standard is not yet available in the market, mainly because the measurement of phasor by means of a quantum standard is significantly challenging. Such a quantum system has not yet been established at any European NMIs, but it would be useful for the calibration of phasor measurement units. This quantum system could also be used for validating new methods which should be developed for the measurement of electrical power.

In EMRP project SIB59 Q-WAVE and EMPIR project 16RPT04 TracePQM, transducers and software of PJVSs were significantly improved. However, to base electrical power measurements on quantum standards will require tailoring existing technology of the key components i.e. PJVSs, transducers and buffers, algorithms and software.

Currently, an NMI wishing to measure electrical power directly using a quantum standard would have to design the measurement setup, develop measurement software and validate the completely new infrastructure. A combined effort is required to promote and increase the number of quantum electrical power standards in NMIs and calibration laboratories.

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 quantum power measurement.

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The specific objectives are

1. To design and realise a practical quantum sampling electrical power standard based on programmable Josephson voltage standards, traceable digitizers and transducers. The quantum sampling standard should be able to measure electrical power, power quality (PQ) parameters and phasor. The target uncertainties are better than 20 μW/VA for power measurements and less than 2 μW/VA for the contribution of the digitizers.
2. To develop software for the operation of the quantum sampling electrical power standard developed in Objective 1. The software should enable measurement control, data processing and uncertainty estimation. Additionally, it should be open source and easily modifiable to control different AC quantum systems.
3. To develop new methods for the measurement of electrical power, and validate those methods using the quantum sampling electrical power standard developed in Objective 1.
4. To promote and increase the number of quantum electrical power standards enabling the measurement of electrical power with low uncertainties in metrological institutes and calibration laboratories.
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 including members of relevant the EMNs or JRPs, to ensure that a coordinated and optimised approach to the development of traceability in this field is developed for Europe as a whole.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this.

In particular, proposers should outline the achievements of the EMRP projects SIB59 Q-WAVE, ENG04 SmartGrid and ENG52 SmartGRid II, and EMPIR projects 15RPT04 TracePQM, 14RPT01 ACQ-PRO, 15SIB04 QuADC and 17RPT03 DIG-AC and how their proposal will build on those.

Joint Research Proposals submitted against this SRT should identify

- the JRP(s) or/and the joint European metrology structure initiative they refer to,
- 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 competitiveness 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 or European Metrology Networks.

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 0.5 M€ for the EU Contribution to any project in this TP, and a minimum of 0.1 M€.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 10 % of the total EU Contribution across all selected projects in this TP.

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, including the related JRP,
- 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 electricity 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.