EMPIR Call 2014 – Industry and Research Potential

Selected Research Topic number: **SRT-i14**
Version: 1.0

Title: Metrology for the electrical power industry

Abstract

Driven by requirements for higher efficiency in electricity grids, new products are currently being developed for higher grid voltages and with lower losses. This document describes the research required to unambiguously prove the quality of these products, which is key to maintain the competitiveness and present leading position worldwide of the European high-voltage electrical power industry. The research involves traceability in testing at the highest voltages and fastest impulses as well as traceability in quantification of losses in key grid components such as power transformers, cables, and HVDC converter stations.

Keywords

High voltage transmission, electricity transport, energy losses, loss measurement, dielectric testing, lightning impulse, energy metering, power transformers.

Background to the Metrological Challenges

In production of equipment for high voltage grids, dielectric testing is performed to verify that the equipment can withstand the operational environment, including high voltage and high current impulses. Methods and schemes for calibration have been identified primarily in IEC 60060-2 [1]. The system voltages are however increasing to levels higher than those covered by this standard, and there is strong need to extend the methods into the ultra-high voltage range.

Traceability of measurements in HV testing is an important tool to ensure high quality and reliability of the tested products. For example, lighting impulse voltage measurement systems are typically calibrated at 500 kV, together with additional measures to extrapolate the linearity up to 2500 kV. Globally increasing transmission voltages now requiring testing at voltage levels exceeding 2500 kV is currently studied within the frame of International Council on Large Electric Systems, CIGRE [2].

Loss measurement on large transformers and reactors are performed using complex measuring systems that rely on extremely precise voltage and current transducers connected to advanced power meters. For large power transformers it is necessary to measure the active power with an uncertainty of better than 3 % at a power factor that may be 0.01, which leads to an accuracy requirement of 0.03 % of the apparent power. Piece-wise calibration of the components is not suitable for calibration of such systems. At present there are no calibration facilities in Europe that provide calibration service for this purpose.

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 traceable measurement and characterisation of electrical power and associated parameters for the electrical power industry.

The specific objectives are

1. To develop methods to extend the voltage range of traceable lighting impulse testing to the ultra-high level of 3500 kV with better than 1 % uncertainty.
2. To develop hardware and methods for the traceable calibration of impulse voltages, using combinations of amplitude and front time, such as those used in puncture testing on insulators. As well as, reference calibration circuits for impulse current measurements with

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ultra-fast rise times in the sub-microsecond range and peak value range of 50 A to several kA, with 0.5 % uncertainty.

3. To produce facilities for the loss measurement of large power transformers, reactors and power capacitors and AC cables. This should include the measurement of active loss power at low power factors in industrial conditions with extreme phase accuracy of 10 µrad at voltages and currents up to 150 kV and 2000 A, respectively. Particular attention should be given to the determination of skin effects for three-phase cables.

4. To develop a measurement system for the accurate determination of total HVDC converter station losses by simultaneous measurement of AC and DC power. The target is to measure a 1 % loss with a relative uncertainty of 3 %. In order to facilitate on-site measurements, a non-invasive current sensor should be developed as part of the measurement system with an uncertainty smaller than 50 µA/A in current and 50 µrad in phase angle.

5. To ensure that the outputs from the JRP are effectively disseminated to, and exploited by the electrical power industry to facilitate the take up of the technology and measurement infrastructure developed by the project.

Proposers shall give priority to work that meets documented industrial needs and include measures to support transfer into industry by cooperation and by standardisation. An active involvement of industrial stakeholders is expected in order to align the project with their needs – both through project steering boards and participation in the research activities.

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 JRPs: ENG07 ‘Metrology for HVDC’ and ENG04 ‘Metrology for Smart Electrical Grids’ and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs to be 1.5 M€, and has defined an upper limit of 1.8 M€ for any project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project. Any deviation from this must be justified.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

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,
- Drive innovation in industrial production and facilitate new or significantly improved products through exploiting top-level metrological technology,
- Improve the competitiveness of EU industry,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the electrical power sector.

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.

Additional information

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

[1] IEC 60060-2: 2010, High-Voltage Test Techniques - Part 2: Measuring systems.

[2] U. Riechert. Proposal for creation of a new working group: Special requirements for dielectric testing of Ultra High Voltage (UHV) equipment. Available: https://www.electrosuisse.ch/fileadmin/user_upload_electrosuisse/Verband/Cigre/TOR/TOR_D1/TOR-WG_D1.36.pdf