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

Selected Research Topic number: **SRT-n09**
Version: 1.0

Title: Loss Measurements on Power Transformers and Reactors

Abstract

Losses in the electricity grid represent large costs and significant CO_2 emissions. Therefore, utilities, supported by Ecodesign Directive regulations, require power transformer manufacturers to unambiguously prove that their products meet the stated efficiency requirements. CENELEC TC14 has expressed a need for improved measurements to increase the accuracy and reliability of grid loss measurements from high-voltage power transformers and reactors. However, this is challenging due to the existing high efficiency of power transformers and reactors and their on-site operating conditions. Thus to address CENELEC's requirements, new measurement systems, calibration facilities and improved uncertainty propagations are needed.

Keywords

High voltage, power industry, power transformers, reactors, loss measurements, Ecodesign Directive, efficiency, calibration.

Background to the Metrological Challenges

An efficient and reliable electricity supply provides transmission grid stability and minimisation of system losses from power generation to the consumer. Driven by the need to reduce transmission losses, new system components such as power transformers and the high voltage reactors (used to help stabilise supply), are undergoing continuous development. A new European Commission Regulation has been issued under the EU Ecodesign Directive specifically targeting losses of power transformers, and as a consequence, power transformer manufacturers now have to unambiguously prove that their products meet the regulations efficiency requirements. Based on this regulation, CENELEC TC14 'Power Transformers' has identified a need for metrology research in the area of high-voltage power transformers and reactors, and given the complexity of these high voltage loss measurements, there is also a need for guidance on determining measurement uncertainties. Consequently, IEC TC14 is currently updating the IEC 60076-19 standard on uncertainties due to losses of power transformers and reactors.

High voltage power transformers and reactors are inherently responsive components, with an extremely low power factor during operation. In a typical load loss test for a high-end power reactor, a 3 % accuracy in measuring load loss at a power factor of 0.001 relies on achieving a challenging 30 µrad accuracy in determining the phase angle between the voltage and current. Thus taking into account the typical scattering of power measurement results, the total measurement uncertainty can easily exceed the prescribed 5 % test limits required by the Ecodesign Directive.

Loss measurements for high voltage equipment are already under study in the EMPIR project ElPow 14IND08, where new measurement and calibration systems are being developed over a restricted voltage range (to 500 V). For power transformer measurements, the ElPow project's uncertainty aim is 50 µW/W, whereas current needs require the improvement of these uncertainties by a factor of 2 – 5.

Therefore, new measurement and calibration systems are needed to extend the test voltage range to at least 230 kV, with current levels of at least 2 kA as well as an overall improvement of measurement accuracy. Achieving low measurement uncertainties on-site in an industrial environment will also require factors such as signal pollution (non-sinusoidal signals) and parasitic elements (EM interference) to be characterised.

EURAMET MSU, Hampton Road, Teddington, Middlesex, TW11 0LW, UK
Phone: +44 20 8943 6666 Email: msu@npl.co.uk
msu.euramet.org

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

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 metrology research necessary to support standardisation in load loss measurements for power transformers and power reactors, to address the need for greater accuracy expressed by CENELEC TC14 “Power Transformers”.

The specific objectives are

1. To develop hardware and improved measurement techniques for highly accurate measuring systems used for loss measurements of power transformers and reactors at very low power factor. The target accuracy is better than 50 µW/W, at voltage levels of up to at least 230 kV, and current levels of up to at least 2 kA.
2. To develop reference facilities capable of validating the outputs from objective 1. The goal is to generating and measuring a system’s active loss power at very low power factors under laboratory and industrial conditions, to enable the validation of system performance. The target accuracy is better than 20 µW/W, at voltage levels of up to at least 230 kV, and current levels of up to at least 2 kA.
3. To determine the effects of using non-sinusoidal test signals on the final accuracy of loss measurements and to produce guidelines for evaluating the complex measurement uncertainties associated with loss measurements for high-power, high-efficiency power transformers and for large reactors.
4. To facilitate the take up of methods, technology and measurement infrastructure developed in the project by the standards developing organisations such as IEC TC14 and CENCELEC TC14. To ensure that the outputs of the project are aligned with their needs, communicated quickly to those developing the standards and to those who will use them, and in a form that can be incorporated into the standards at the earliest opportunity. In addition, to disseminate the outputs of the project to market surveillance authorities, and ensure their take up by instrument and power transformer manufacturers.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.6 M€, and has defined an upper limit of 0.8 M€ for this 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 industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

In particular, proposers should outline the achievements of the EMPIR JRP 14IND08 ElPow and how their proposal will build on these.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects. The proposal must name a “Chief Stakeholder”, not a member of the consortium, but a representative of the user community that will benefit from the proposed work. The “Chief Stakeholder” should write a letter of support explaining how their organisation will make use of the outcomes from the research, be consulted regularly by the consortium during the project to ensure that the planned outcomes are still relevant, and be prepared to report to EURAMET on the benefits they have gained from 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,

- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the electricity generation and supply sector.

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

[1] CEN/CENELEC identified this topic as one of their priorities. Details are available at: https://msu.euramet.org/current_calls/pre_norm_2017/documents/SRT_related_CEN_priorities/cen_priority_002_2017.pdf

The following Standardisation requests from the EC may be relevant:

[2] Mandate M/495 Standardisation mandate to CEN, CENELEC et ETSI under Directive 2009/125/EC relating to harmonised standards in the field of Ecodesign

[3] Amendment to the mandate M/495 amendment no. 2 to M/495 technical update (Annex B of M/495)- Details of request to CEN, CENELEC and ETSI for standardization in the field of small, medium and large power transformers (ENTR LOT 2)