European Partnership on Metrology
Call 2023 –Fundamental Metrology, Industry, Normative and Research Potential

Selected Research Topic number: **SRT-i21**
Version: 1.0

Title: Electric energy and supply reliability

Abstract

The lower power quality and shrinking inertia of renewable generation puts new demands on monitoring, regulating and balancing of energy flows in the electricity grid. This calls for new high-voltage (HV) metrology solutions in support of the HV manufacturing industry. Specifically, there is a need to develop new HV measurement technology in four areas: wideband live connectable current or voltage sensors to monitor and calibrate substation instrumentation; new capability for loss determination in power transformers caused by grid harmonics; new methods for loss determination of HV-AC cables; and new partial discharge (PD) monitoring techniques for fault detection and localisation in HV-DC cables.

Keywords

Power quality, harmonics, transformer, cable losses, partial discharge, HVDC, fault detection

Background to the Metrological Challenges

In the ongoing expansion of the HV power grids, with new power sources from renewables like large solar and wind parks, the power is injected into the transmission grid by adding new substations. However, the wind, solar and battery power sources use converters/inverters to inject energy into the grid which pollutes it with harmonics. Harmonics will inevitably lead to increased losses in power transformers, especially in the older types, and in power lines and HV cables in the power grid. Power transformers of older types are not designed to transmit harmonics leading to excess losses and overloading. HV cables are used for new overseas interties, for replacement of existing land-based overhead lines or selected for bulk transmission in Europe, e.g., in Germany for transmitting electricity from the wind farms in the Baltic Sea to Bavaria. Losses in HV-AC cables from harmonics need to be minimized not to overload the interties. There are cases where HV-DC interties from Sweden got overloaded by harmonics from a rectifier.

Furthermore, HV grid operation needs new reference instrumentation for calibration of instrumentation in substations and monitoring of harmonics to ensure stability and reliability in the presence of a steadily growing portion of renewables polluting the grid. Especially old substations need to be updated to be able to measure and monitor power quality. Metrology for monitoring of harmonics is crucial if energy storage will be used to compensate for the loss of grid inertia and reduction of harmonics.

There is also a need for new metrology to determine the impact of higher harmonics on the losses of power transformers. New HV-DC links on land are being installed in the transmission grids to enable bulk transmission of power over long distances. There is a strong industry need to support the current methods for condition monitoring using traditional PD detection below 150 kHz, applying new metrology working up to 30 MHz.

In addition, it is essential to address the needs of EMN for Smart Electricity Grids which provides support for standardisation, testing, and the research and development of national smart grid development and implementation strategies. By promoting a reliable and robust measurement infrastructure, the EMN for Smart Electricity grids will help Europe to meet its sustainability and climate change goals, and support the energy systems of the future.

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 metrology research necessary to support standardisation and traceable tools for HV condition monitoring and fault detection and means for traceable determination of losses in HV transformers and HV cables.

The specific objectives are:

1. To perform on-site calibration of instrument transformers in substations with minimised downtime or even live connection with reference instrumentation based on optical sensors. To use these sensors to upgrade/retrofit existing instrument transformers for use in higher harmonics measurements, and power quality monitoring. Target measurement uncertainty 0.05 % (of fundamental) for currents up to at least 1 kA.
2. To develop reference instrumentation with a bandwidth of at least 2 kHz for determination of the impact of grid harmonics on power transformer losses with a target uncertainty of better than 1 % of the loss power. To realise HV capacitor reference for loss factor determination up to 30 kV with an uncertainty of 5 ppm.
3. To develop new traceable metrology for determination of skin effect of HV-AC cables using both calorimetric and electrical methods up to 3 kA with 1 % uncertainty, including a study of the effect of harmonic currents. To demonstrate the new method on two samples from cable manufacturers.
4. To develop new measurement capabilities for PD measurements in DC cables at 100 kV and above for use in monitoring systems for detection, classification and localisation of defects or damage before breakdown. To demonstrate the new method on at least two samples of HV-DC cable with known defects (provided by an industrial partner).
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by standards developing organisations (CLC/IEC TC14 “Power transformers”, TC38 “Instrument Transformers”, TC Electricity and Magnetism and TC42 “High-voltage and high-current test techniques”), by the EMN for Smart Electricity Grids and end users (e.g. manufacturers and network operators).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. 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 EMPIR 17NRM01 TrafoLoss, EMPIR 14IND08 ElPow, 19ENG02 FutureEnergy projects and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.9 M€ and has defined an upper limit of 2.3 M€ for this project.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 35 % of the total EU Contribution across all selected projects in this TP.

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated 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,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Facilitate improved industrial capability or improved quality of life for European citizens in terms of personal health, protection of the environment and the climate, or energy security,
- Transfer knowledge to the HV manufacturing 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 the Partnership 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.