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

Selected Research Topic number: **SRT-g06**
Version: 1.0

Title: Traceable efficiency of power electronic devices and systems for electro-mobility

Abstract

In 2011, the European Commission adopted an ambitious roadmap, which proposes to build a competitive and sustainable transport system by 2050. Electrical mobility has much potential to contribute to this roadmap but the characterisation of Power Electronic Devices and Systems (PEDSs), in terms of energy efficiency and energy loss, still lacks standardised procedures and traceability. Proposals addressing this SRT should develop a metrological framework and measurement infrastructure enabling accurate and traceable measurements of energy loss and energy efficiency of power electronic devices and systems used for electro-mobility.

Keywords

Energy loss, energy efficiency, energy metering, power electronics, voltage and current measurements, electro-mobility, energy storage systems, supercapacitors

Background to the Metrological Challenges

Electric vehicle sales in Europe reached 408 000 units in 2018, 33 % higher than in 2017. PEDSs are key in electrical mobility applications as they convert electric energy between different forms by e.g. converting between alternating current (AC) and direct current (DC)), changing the voltage amplitude or frequency, or some combination of these. The energy management in electrical traction has undergone revolutionary changes and currently PEDSs can operate at high voltages (kV), high currents (kA) and high speed (kHz), with commutation time as low as some tens of nanoseconds and with declared efficiency over 99 %. All together this makes the accurate measurement of energy loss or energy efficiency very challenging. There is no standard procedure for these measurements and no service is available at the NMIs. Therefore, the values declared by the manufacturers of these devices are not traceable or obtained by standardised procedures and therefore are not reliable. This situation impairs the development of more efficient devices and systems, and can only be solved by a comprehensive characterisation of their efficiency in different conditions, including non-stationary situations.

Variable-speed motor drives and energy storage systems can greatly benefit from energy saving associated with improved devices. Electric motors and their systems are the single largest electrical end-use. It is estimated that currently electric motor-driven systems account for 43 % to 46 % of all global electricity consumption, giving rise to about 6.040 million tonnes of CO_2 emissions. With electric car mobility, this is expected to increase even more. Storage systems are the key technology of “fully” electrical vehicles, in particular cars, ships and new autonomous trains.

Super capacitors are often used in DC tramway and light railway lines to increase the amount or regenerated energy, to reduce transmission losses on lines reducing voltage drops and to increase peak power capacity of the line. The design and specifications for these systems are relatively sensitive to the efficiency and reliability of the storage systems adopted. As a consequence, the energy costs are affected by the storage system and converter.

The efficiency of a power electronic system that manages charging/discharging is of preeminent importance. Therefore, for both variable-speed motor drive and energy storage systems, a specific metrological infrastructure is necessary for providing reliable information on the energy efficiency of the whole chain, taking into account different real operational conditions.

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 traceable measurement and characterisation of power electronic devices and systems used for electro-mobility.

The specific objectives are

1. To develop reference measurement systems and procedures for the accurate evaluation of commutation losses arising i) from a single power electronic component (e.g. diode, thyristor) and ii) from switching frequency. Traceability of energy loss measurements will be established for electronic components with power rating up to 10 kW and commutation time down to 10 ns under operating environmental conditions.
2. To develop measurement systems and procedures for the traceable characterisation of the energy efficiency of high frequency – high power converters (AC/AC – AC/DC – DC/AC – DC/DC), accounting quasi DC (DC plus ripple) and distorted AC (fundamental plus harmonic and interharmonic) conditions. Traceability will be established for converters with input voltages up to 2 kV and power rating up to 100 kW. Different supply, load and operating environmental conditions will be considered.
3. To develop the metrological infrastructure required for ensuring traceability of measurements of the efficiency of electrical traction systems, including power electronic drive (DC/AC or AC/AC) and electrical motor, for power size up to 1 MW and input voltage up to 2 kV. Different supply and load conditions, including power quality issues, should be investigated and storage systems should be tested in real world conditions, including non-stationary situations.
4. To develop the metrological infrastructure required for ensuring traceability of measurements of the efficiency of the energy storage system used in electric traction. This should include the effects of the power electronic drive (AC/DC or DC/DC) and different type of storage technologies (batteries and supercapacitors). Different supply and load conditions, including power quality issues, will be investigated and the storage systems should be tested in real world conditions, including non-stationary situations.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (accredited laboratories), standards developing organisations (EN, ISO) and end users (e.g. automotive manufacturers).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research, the involvement of the appropriate user community such as industry, standardisation and regulatory bodies is strongly recommended, both prior to and during methodology development.

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 project 16ENG08 MICEV and how their proposal will build on that.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.0 M€, and has defined an upper limit of 2.3 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 35 % 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,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the transport 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.