

Title: Precision non-invasive measuring of high DC power

Abstract

As part of Europe's drive towards net zero, e-mobility (i.e. the use of electric vehicles (EV), battery storage and photovoltaic (PV) systems) have experienced a significant increase during the last decade and has become a major part of the energy sector. These 3 areas use DC current and consequently need accurate measurements of DC power. However, currently there is no reliable method for measuring DC power directly in these applications in Europe and hence power consumption has to be measured using AC. This current situation is undesirable and impacts Europe's move towards greener energy, therefore new practical metrological capabilities for measuring DC power are needed. These new capabilities include methods and devices for non-invasive high accuracy DC power measurements that also go beyond the current state of the art (i.e. integrating magnetic fields with magnetic fibre). The new methods and devices also need to be validated in laboratory and real-world applications and against existing methods to support their uptake by end users in the energy and transport sectors and the metrology community.

Keywords

DC power, non-invasive measurement, DC current, magnetic field, magnetic fibre, e-mobility

Background to the Metrological Challenges

Currently in Europe, Annex MI-003 of the Measuring Instruments Directive (MID) 2014/32/EU covers AC meter regulations. However, DC meters are not specifically addressed by the MID. This means that electricity delivery (e.g. EV charging) meters are only legally regulated as AC meters. Whilst such AC meters can measure the input side of the charger (i.e. power supply and billing to the service provider), they cannot measure the losses that occur during conversion between AC and DC. AC to DC conversion is needed as national grids provide AC power whereas batteries can only store DC. Thus, it has to be converted either by a converter integrated into EV charging stations or with an on-board AC-DC converter. Overall, the net result is an unknown difference between the energy paid for and the energy 'really' delivered. As it is expected such charging will grow in popularity in the near future the improvement in consumer confidence in e-mobility charging stations is essential for a smooth transition away from fossil fuels.

Despite DC meters not being specifically addressed in the MID, DC power is widely used in the energy sector, including high voltage (HV)DC grids. For example, a HVDC grid is currently being built in Germany to connect the north (where production of electric energy from renewable sources is concentrated) to the south (where demand for energy is higher). Hence, accurate DC power measurements will be vital for the future control of this HVDC grid and its distribution of energy.

The use of existing DC meters is currently hampered by the lack of written standards and test requirements. This also means that metrological testing and calibration cannot be satisfactorily performed by existing test laboratories or under real-world applications. Thus, in order to improve the situation in Europe regarding DC power measurement, new metrological capabilities are needed. These new capabilities should go beyond the current state of the art and include methods and devices for non-invasive high accuracy DC power measurements. The capabilities also need to be validated in laboratory and real-world applications to support their uptake by end users and the metrology community.

The current state of the art for DC power measurements devices includes a novel method of exact magnetic field sensing and line integration (that enables the current measurement independent of areal distribution of the magnetic field) along the path required for specific application. The sensor based on the method can be used as precision DC current sensor, in the range from a fraction of A to tens of kA with negligible power and space requirements. Due to the true line integration, the measured current value is independent of areal

distribution of the magnetic field, and therefore, the initial laboratory calibration is valid for field applications as well. The method is also applicable for a variety of instruments exploiting magnetic field evaluation.

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 metrology capability in high accuracy non-invasive measurements of DC power.

The specific objectives are

1. To develop a measurement device for high accuracy non-invasive measurement of DC power for the measurement ranges 1 A – 1200 A and 1 V – 1000 V, with a target uncertainty of ± 0.02 %. The device will go beyond the current state of the art (i.e. Grno 2017) and be based on magnetic field integration with magnetic fibres. In addition, the device design must take into account (i) easy integration into existing systems (i.e. small dimensions, light weight and low power consumption), (ii) its interconnect with supporting devices (i.e. power sources, control units) and communication interfaces, (iii) software control, (iv) sampling, and (v) the required form of output.
2. Using the device from Objective 1, to perform non-invasive measurement of DC power in laboratory and real-life operating conditions, and to compare the device with existing methods for measuring DC power. The results will be used to determine the achievable real life measurement (i) ranges, (ii) accuracy, and (iii) uncertainty for the device, and to identify (and mitigate) measurement deviations.
3. Using the results obtained from Objective 2 to optimise the accuracy and reliability of the developed measurement device from Objective 1, (target uncertainty 0.02 % for 1 A – 1200 A and 1 V – 1000 V). The DC power measurement device will be tested (i) over short and long-term durations, (ii) with a variety of conditions (e.g. temperature, humidity, mechanical shocks during device transportation) that simulate real-life measurement conditions, and (iii) against existing methods for measuring DC power. In addition, to produce robust calibration procedures and performance tests for the optimised DC power measurement device.
4. Using the optimised device from Objective 3, to measure DC power (loss and usage) during charging for e-mobility and to assess the device's performance against existing methods. Using the results, to make recommendations for the use of the optimised device, for measuring high accuracy non-invasive measurements of DC power with e-mobility.
5. To facilitate the take up and long-term operation of the capabilities, technology and measurement infrastructure for high accuracy non-invasive DC power measurements developed in the project, by the measurement supply chain (NMIs/DIs, calibration and testing laboratories), and end users (e.g. industry, instrument manufacturers, regulators). The approach should be discussed within the consortium and with other EURAMET NMIs/DIs, e.g. via EURAMET TC-EM and EMN Smart Grids, to ensure that a coordinated and optimised approach to the development of traceability in this field is developed for Europe as a whole.

Joint Research Proposals submitted against this SRT should identify

- the particular metrology needs of stakeholders in the region,
- the research capabilities that should be developed (as clear technical objectives),
- the area for which the capabilities will be built (Green Deal, Digital Transformation, Health, Integrated European Metrology, Industry, Normative or Fundamental Metrology) and in which future main call the developed research capabilities are planned to be employed,
- the impact the developed research capabilities 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.

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

The development of the research potential should be to a level that would enable participation in other TPs.

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 expects the average EU Contribution for the selected JRPs in this TP to be 0.7 M€ and has defined an upper limit of 0.9 M€ for this project.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 20 % 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,
- Provide a lasting improvement in the European metrological capability and infrastructure beyond the lifetime of the project,
- 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 energy and transport sectors 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 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.