EMPIR Call 2020 – Fundamental, Industry and Normative

Selected Research Topic number: **SRT-n01**
Version: 1.0

Title: Standardisation of measurements for DC electricity grids

Abstract

The increasing use of distributed energy generation and storage has led to local DC trial grids as an extension to traditional AC distribution networks. Like the existing AC grids, DC grids must fulfil power quality (PQ) limits to guarantee reliable operation and to protect customers. However, knowledge about PQ in public DC systems and its impact on DC electricity metering is lacking, as is the related metrology and standardisation. Proposals addressing this SRT should facilitate further development and employment of DC grids and to ensure customer confidence, in response to needs expressed by CLC TC8X WG1 on voltage characteristics of public electricity supply, and IEC TC13 WG11 on electricity meter testing.

Keywords

Electricity grids, DC grids, DC metering, voltage sensors, current sensors, power quality, LVDC grids, test waveforms, dynamic voltage, current signals, in-rush current, voltage dips, current ripple

Background to the Metrological Challenges

Over the last two decades a paradigm shift in the way of dealing with energy generation and consumption has increased the attractiveness of local DC grids as an extension to traditional AC distribution networks. A strong focus on energy efficiency and sustainability has caused a search for energy sources other than fossil fuels. As a result, renewable energy sources (RES) such as wind and solar energy are becoming more and more reasonably priced, and consequently, distributed generation is growing. Simultaneously, LED lighting has shown to be a much more efficient way of illumination compared with the old-fashioned incandescent lamps and is taking over rapidly. Many of these sustainable technologies are fundamentally DC, requiring power inversion to connect to the AC grid.

These developments have caused a different view on managing the electricity distribution, away from the centralised model used originally to design electricity grids. Nowadays the DC contribution of energy generation and consumption is increasing. For instance, photovoltaic cells (PV) and other RES produce DC power, storage systems such as batteries and supercapacitors are intrinsically DC, and electric vehicles (EV) and all electronic devices operate on DC power. There is a realisation amongst grid operators that utilising local low voltage DC (LVDC) grids means that less energy is wasted in the conversion process.

Standardisation of DC grid control is following rapidly, but standardisation of measurements in DC grids is still lacking. For instance, for DC grids, PQ issues such as ripple, inrush currents, voltage fluctuations and short circuit events, are different in nature from those in AC grids in terms of dynamics, duration, and magnitude. Therefore, CLC TC8X WG1, responsible for the standard EN 50160 on voltage characteristics of public electricity supply has defined DC PQ as a new work item, and so is IEC TC8 JWG9 “LVDC distribution”. Within the STAIR EMPIR initiative, CLC TC8X WG1 expressed a need for metrology support to obtain proper PQ definitions, a practical measurement guide and realistic and well-defined PQ limits for DC power systems.

Another important issue regarding DC grids is the accurate measurement of power and energy for billing purposes. In most countries, electricity meters are type tested with respect to standards issued for AC grids only. In China, however, a recommended GB standard was published for DC electricity meter testing in 2017. Therefore, IEC TC13 WG11 has developed a new standard for DC electricity meter testing, IEC 62053-41, a first edition of which is expected to be published in 2020. Within the STAIR EMPIR initiative, they expressed a need to investigate additional specific metrological aspects of DC meters, which should be included in a future revision of this standard.

In order to develop DC PQ limits for equipment, the compatibility levels must first be established by making traceable on-site measurements of the various PQ phenomena that exist. DC grids exhibit several particular PQ conditions, such as ripple and in-rush current, which can lead to malfunction or damage to utility and customer equipment. Special measurement equipment and methodologies are required to conduct the required surveys for setting compatibility levels. This same equipment will be the basis of future "planning level" surveys which will be carried out by utilities to manage the PQ levels in future DC networks.

Extensive experience has been obtained from earlier PQ measurements in distribution grids and related standardisation work. However, these measurements and standardisation activities only relate to AC grids. Since the nature of PQ phenomena in the upcoming DC grids is different from those at AC, measurement methods and standardisation of PQ in DC grids are urgently needed. Future grid operators have to be able to assure that users connected to their DC grids are protected from hazardous disturbances in the form of new regulations setting limits to those disturbances and that they can trust their energy bills because the metering equipment is immune to those disturbances.

There are currently several trials of DC grids to assess the benefits and technical barriers (e.g. business park site in Flevoland in the Netherlands, Living Lab of Smart City Málaga in Spain). These sites feature for example 100 kW PV generation, 10 kW wind turbines, 50 kWh storage systems, 100 kW bi-directional chargers, electrified transportation, PV streetlights and canopies, and EV chargers. On-site measurements with sufficiently high accuracy and sampling rate to capture fast phenomena and broadband disturbances to determine the nature of the PQ phenomena occurring in such grids have not yet been performed.

Whereas traceability for AC power and PQ for AC systems is well established, metrology infrastructure for DC needs to be developed. For stationary voltage and current without disturbances no new calibration and measurement capabilities (CMC) are necessary, but for dynamic DC signals and DC disturbances there are currently no CMCs defined and no measurement standards available.

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 PQ parameters to support standardisation in further development and employment of DC grids.

The specific objectives are

1. To develop on-site measurement equipment and to capture dynamic voltage and current signals in real low voltage DC (LVDC) grids, at voltage and current levels up to 1 kV and several hundreds of amperes, respectively, with target uncertainties below 0.1 % taking into account the presence of AC ripple and other disturbances.
2. To analyse on-site measurement data in real LVDC grids to obtain a set of DC power quality (PQ) parameter definitions and electricity meter test waveforms, and to develop reference systems for measuring DC PQ parameters and DC energy taking into account the presence of defined PQ disturbances.
3. To define equipment specifications and methodologies for PQ "compatibility level" and "planning level" surveys in LVDC grids for DC parameters such as in-rush current, voltage dips, voltage and current ripple.
4. To contribute to a revision of EN 50160 by providing the data, methods, guidelines and recommendations, which are necessary for the standardisation of voltage characteristics of public electricity supply, to CLC TC8X WG1. To contribute to a revision of IEC 62053-41 by providing the data, methods, guidelines and recommendations, which are necessary for the standardisation of DC electricity metering, to IEC TC13 WG11. In addition, to contribute to the standards development work of the technical committees IEC TC85 WG20 and IEC SC77A WG9. Outputs should be in a form that can be incorporated into the standards at the earliest opportunity and communicated through a variety of media to the standards community and to end users (e.g. electric suppliers for general public and industrial applications).

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Regulatory body or 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.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this. In particular, proposers should outline the achievements of the EMRP/EMPIR projects ENG52 SmartGrid II, 16ENG04 MyRailS, 17NRM02 MeterEMI and 18NRM05 SupraEMI and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.8 M€, and has defined an upper limit of 1.0 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution across all selected projects in this TP.

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,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the electricity 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

CEN/CENELEC identified this topic as part of their priorities. Details are available at:

https://msu.euramet.org/current_calls/pre_norm_2020/documents/cen_priority_011.pdf

https://msu.euramet.org/current_calls/pre_norm_2020/documents/cen_priority_012.pdf