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

Selected Research Topic number: **SRT-n08**
Version: 1.0

Title: Measurement methods and test procedures for assessing accuracy of Instrument Transformers for Power Quality Measurements

Abstract

The IEC TC38 “Instrument Transformers” (IT) has expressed the need for research activities on the topic of accuracy tests for ITs used for Power Quality (PQ) Measurements (PQM). ITs are essential for PQM in distribution and transmission grids. However, while PQ indices and measuring instruments are well standardised, no Standards about IT for PQM exist. Literature shows that ITs can introduce errors up to some percent in PQM. Therefore, proposals submitted in response to this SRT should aim to develop specific PQ-relevant indices to assess IT performance, test procedures, requirements for reference setups and methods to evaluate the uncertainty contributions of ITs to PQM. Guidelines and recommendations for the calibration of ITs used in PQM will be given to IEC TC38.

Keywords

Instrument Transformer (IT), Low Power Instrument Transformers (LPIT), Digital Low Power Instrument Transformers (DLPIT), Calibration, Power Quality (PQ), Test Procedures, Reference Setup, Uncertainty Evaluation, Influence factors, Phasor Measurement Units (PMU).

Background to the Metrological Challenges

In the last decades, not only electricity distribution systems (DSs) but also transmission systems (TSs) have experienced the increase of non-linear (essentially AC/DC or AC/AC converters) or intermittent (arc furnaces, etc.) connected loads and distributed renewable energy sources (photovoltaic and wind with DC/AC or AC/AC energy converters) injecting various type of disturbances into the grid. These disturbances may cause malfunctioning or damages as e.g. lifetime reduction in dielectric insulation, relay tripping, or over-heating in motors. Moreover, they are often the cause of voltage reductions, increase of interruptions, which, in turn, are the source of production outages. Therefore, it is necessary to accurately measure the power quality (PQ) phenomena, to verify their compliance with the established limits, identify problems and localise PQ disturbance sources. Available Standardisation of PQ measuring instruments, besides ensuring repeatability and reproducibility of measurement, constitutes an added value in legal disputes, related to bad PQ in the supplied voltage or in the absorbed current, frequently occurring between players of the electrical grids. However, PQ measurement chains in DSs and TSs must necessarily include ITs, in order to scale voltage and current down to levels compatible with the input ranges of PQ instruments. Particularly for inductive ITs, there is a lack of knowledge on their behaviour in perturbed situations. No detailed and focused indication is provided by any standard or in literature on the performances of these devices in the presence of disturbance and/or on specific tests to be performed to characterise them. Consequently, manufacturers of PQ measuring instruments can only perform accuracy verification and declare the accuracy performance of the instrument itself, that is excluding the ITs. As to DS and TS operators (TSOs or DSOs), they need to accurately measure the PQ to take decisions and actions for its mitigation to further improve the grid. Currently, they build their own measurement reference setup and define internal procedures to perform specific accuracy tests on ITs. In case of litigation, such an internal procedure would be questioned. In this context, the IEC TC 38 "Instrument transformers" has assigned the task to TC38/WG47 “Evolution of Instrument transformer requirements for the modern market” to establish Task Forces to study the topic of extended frequency response qualification of Instrument Transformers for PQ measurement and travelling waves relaying applications and to study the topic relevant to the effects of combined influencing factors on the accuracy of Instrument Transformers. In addition, TC38 has identified a series of needs and open issues concerning the definition of measurement methods and test procedures for assessing the accuracy performance of ITs intended to be used for Power Quality Measurements, which have been submitted to the STAIR/EMPIR Committee.

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In the EMRP projects ENG04 Smart Grids and ENG52 Smart Grid II, setups for the characterisation of voltage ITs up to 20/√3 kV and a bridge for current transformers up to 20 kHz have been realised. In the EMRP JRP ENG61 Future Grid, setups for the calibration of LPITs (low power ITs) and DLPITs (LPITs with digital output) at 50/60 Hz have been realised as well as setups for the calibration of test sets for DLPIT testing. The EMPIR project 17IND06 Future Grid II (in progress) is focused only on DLPITs and builds measurement setups for voltage and current DLPIT testing up to 400/√3 kV, 2 kA, 9 kHz. The EMPIR project 15RPT04 TracePQM is focused on the establishment of metrological capability in electrical power and PQ sampling measurements including the development of an open software tool for power and PQ measurements.

A considerable number of standards have been published on Power Quality Measurements. International Standardisation Development Organisations (SDOs) (IEC, CENELEC, IEEE, etc.) have faced the issues by defining the PQ as “characteristics of the electricity at a given point on an electrical system, evaluated against a set of reference technical parameters”. Available standards deal with: i) limits for disturbances in public DSs, ii) limits for disturbances for industrial or civil plants, iii) measurement methods for PQ indices, and iv) test methods for PQ measuring instruments. On the other hand, the standards for ITs are focused on accuracy verification just at power frequency (50/60 Hz). Only IEC EN 60044-8 and 61869-6 for a small subset of ITs deal also with the verification of accuracy at harmonic frequencies. However, these standards are limited to signals of reduced amplitudes, and give no indications neither on possible setups to perform the tests nor providing methods for the uncertainty assessment. The only official document from a SDO is the technical report IEC TR 61869-103, which summarises the main PQ indices, gives an overview of the main types of ITs and the expected impact on PQ indices. It specifically states that for most IT types there are no data available in literature and suggests a series of open issues. This is pointed out in the submitted need of TC38 to the STAIR/EMPIR Committee. The IEC TR 61869-103 gives just schematic indications on possible setups for test execution and some test conditions. The gaps in this report are: i) no specific performance indices for ITs versus PQ indices are defined, ii) no requirements for the reference setup, iii) no specific test conditions are indicated, and iv) no methods for uncertainty evaluation are specified. Recent papers have shown that ITs may suffer from intrinsic non-linearity and can introduce errors much higher than the declared accuracy class in the measurement of harmonic components. Moreover, environmental conditions, like temperature or radiated electromagnetic field, may additionally influence the IT to go beyond the declared accuracy class even at power frequency. However, all the potential effects of ITs on the measurements of PQ indices have not been addressed in literature and data for a structured knowledge and classification of their behaviours is missing.

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 in IEC TC38 instrument transformers for power quality measurements.

The specific objectives are

1. To define the accuracy and uncertainty limits of instrument transformers (ITs) in PQ measurements (e.g. the measurement of harmonics, interharmonics and other PQ disturbances).
2. To establish suitable reference measuring systems for ITs and methods for the evaluation of the relevant uncertainty contribution of ITs to PQ indices.
3. To establish traceable test procedures for reference setups to calibrate ITs used for low and high voltage PQ measurements by covering limits for PQ disturbances in the available Standards.
4. To evaluate the performance of ITs in PQ measurements in the presence of more than one influence factors (e.g. Temperature and temperature gradients, adjacent phases, proximity effect, vibrations and Electro Magnetic Interferences).
5. To contribute to a revision of technical report IEC/TR 61869-103 as well as the standards in the IEC 61869 family product (e.g. 61869-1, 61869-6, etc.) by providing the data, methods, guidelines and recommendations, which are necessary for the calibration of ITs used in PQ measurements, to IEC TC 38. 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 (Transmission system operators, distribution system operators, Customers).

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 EMPIR projects 17IND06 Future Grid II (in progress) and 15RPT04 TracePQM 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 power quality 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

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] CEN/CENELEC priority 2019/09

[2] M/349 Mandate addressed to CEN, CENELEC and ETSI for the elaboration of a feasibility study in the area of hydrogen and fuel cells