EMPIR Call 2017 – Industry, Fundamental, Normative and Research Potential

Selected Research Topic number: **SRT-i09**
Version: 1.0

Title: Metrology for the next-generation digital substation instrumentation

Abstract

The decentralisation of energy generation due to greater use of renewable sources is causing an unprecedented shift in power flow away from the traditional top-to-bottom model. To address this, future electrical power grids will require real-time control and monitoring systems to ensure stability and security. Therefore, proposals in response to this SRT should aim to build on the work of the project ENG61 FutureGrid by further extending the metrological infrastructure for digital sensor technology, improving digital data processing, and by applying new and secured network time synchronisation protocols.

Keywords

Electrical power grid, real-time control, digital sensor technology, digital substation, secure time synchronisation, stand-alone merging units.

Background to the Metrological Challenges

This research topic builds on the results of the project ENG61 FutureGrid. The most important needs for that project were identified as “harmonics and other power quality parameters”, “calibration of equipment operating within the digital environment” and “instrument transformers based on different transduction principles”. To address these, calibration facilities for non-conventional sensors under stationary conditions, improved analogue sensors to establish references for power quality parameters, and an emerging transducer technology were created.

However, due to the wide scope of the needs, some issues remain unaddressed. These are mainly focussed on metrological real-time control and monitoring systems required for reliable and stable operation of electricity grids. Therefore further work on the transition from the analogue instrument transformer technology of present substations to digital substations is needed. This includes the development of calibration methods for analogue substations as well as for those equipped with modern IEC61850 communications. A new metrological infrastructure is also required to close the gap in the traceability chain for fully digital operated substations, needed for the successful transition of the present electricity grid towards a modern future power grid.

Time synchronisation is usually achieved via ordinary GPS receivers with accuracies in the range of microseconds. Current research on the use of Phasor Measurement Units (PMU) in distribution networks has identified the need for higher accuracy. Research has demonstrated that timing synchronisation over short or medium distance Precision Time Protocol (PTP) technology and optical fibres can improve the accuracy provided by GPS, but there is a lack of established approaches which combine good security properties with high precision. In addition, GPS signals are easily jammed and can also be spoofed. Using network-based time synchronisation protocols like Network Time Protocol (NTP), PTP or one of their variants, it is possible to secure communication of these protocols via established external security protocols (such as TLS). However, this method can significantly degrade precision. New synchronisation protocols, such as White Rabbit can therefore be profitably applied to the newly-developed sensors from the project ENG61FutureGrid, as well as PMUs in order to get increased phase accuracy. Moreover, the exploitation of other media, as power lines, can be used to implement synchronisation techniques in order to have an alternative approach with similar accuracy.

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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 traceability and synchronisation of measurements in substations using digital data processing protocols.

The specific objectives are

1. To validate new digital instrument transformer (IT) technology for integration in digital substations, and to establish calibration methods for dynamic testing of ITs for real-time monitoring systems associated with power quality (PQ) and synchrophasor measurements. In addition, to develop validated and traceable test systems for digital ITs and novel sensors.
2. To develop validated techniques and algorithms for the synchronisation of sampling to a common time reference within and between digital substations. In addition to develop reference standards for the calibration of instruments with digital input or output, in order to support the transition of substations with analogue, conventional instrument transformer technology to digital substations. Furthermore to evaluate the feasibility of increasing sampling rates beyond those specified in IEC standards, and the effects of geographically distributed sampled measurements on the final accuracy of power/energy measurements.
3. To develop metrological tools for the characterisation of devices that exploit sampled values in digital substations for applications such as metering and power quality measurements. In addition, to evaluate the implementation of phasor measurement units (PMUs) based on sampled values, more specifically in terms of their limitations due to latency, computation time and the characterisation of errors.
4. To develop traceable reference standards for the verification of time and synchronisation methods. To evaluate the suitability of digital time synchronisation technologies such as PTP and White Rabbit (i) for secure and accurate time dissemination to digital substations and distribution networks and (ii) for geographically distributed power quality and PMU measurements. In addition, to assess security integration of such digital time synchronisation technologies, whilst preserving precision for time stamping.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (instrument manufacturers), standards developing organisations (IEC TC38 WG 50, IEC TC57 WG 10, IEEE TC39) and end users (energy distribution companies). To provide guidelines for digital measurement interoperability and recommendations for Standards Developing Organisations (e.g. IEC TC38 WG 50, IEC TC57 WG 10, IEEE TC39).

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 EMRP project ENG61 FutureGrid and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.5 M€, and has defined an upper limit of 1.8 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project.

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 energy distribution 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.