EMPIR Call 2016 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-g17**
Version: 1.0

Title: Real-time metrology for future power grids

Abstract

The decentralisation of energy generation due to renewable energy is causing a shift in the power flow away from the traditional top-to-bottom model. Consequently, future electrical power grids will require real-time control and monitoring systems to ensure stability. The geographical distribution of the substations with their associated high voltage sensors and many smart meters must be managed in a synchronised fashion, with the aid of digital communication for real-time control. Proposals in response to this SRT should aim to build on the work of ENG61 FutureGrid by further extending the metrological infrastructure for sensor technology, improving digital data processing using the IEC 61850-9-2 protocol, and by applying new and secured network time synchronisation protocols.

Keywords

Smart grid, real-time control, transducer technology, digital energy metering, digital substation, secure time synchronisation, clock accuracy, stand-alone merging units

Background to the Metrological Challenges

This research topic builds on the results of 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 remain unaddressed. These are mainly focussed on metrological real-time control and monitoring systems required for reliable and stable operation of electricity grids. This research topic supports the transition from the analogue instrument transformer technology of present substations to digital substations. Therefore calibration methods should be developed for analogue substations as well as for those equipped with modern IEC 61850 communications. A new metrological infrastructure is 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. Another aspect is that there is a lack of established approaches which combine good security properties with high precision. 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 (like 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 of FutureGrid, 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.

EURAMET MSU, Hampton Road, Teddington, Middlesex, TW11 0LW, UK
Phone: +44 20 8943 6666 Email: msu@npl.co.uk
msu.euramet.org

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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 protocol.

The specific objectives are

1. To establish calibration methods for the dynamic testing of instrument transformers for real-time monitoring systems. A set of test systems for different types of instrument transformers and sensors associated with power quality and PMUs should be developed.
2. To support the transition of substations with analogue, conventional instrument transformer technology to digital substations by introduction of suitable references for calibration of instruments with digital input or output. This requires the development of techniques and algorithms for the synchronisation of sampling to a common time reference within and between substations and will allow investigation of the effect on the final accuracy of power/energy measurements.
3. To develop tools for the assessment of devices that exploit sampled values in digital substations for metrology applications such as metering and power quality measurements.
4. To evaluate the suitability of technologies such as NTP, PTP and White Rabbit for secure time dissemination to digital substations and distribution networks for power quality and PMU data. This should involve an assessment of security integration while preserving precision for time stamping of smart meter energy data. In order to improve accuracy and reduce latency, alternative synchronisation techniques based on the ISO/OSI physical layer level rather than the network layer level will be evaluated and traceable references will be developed to verify the new timing and synchronisation methods.
5. To carry out an evaluation of the market availability and deployment of IEC 61850-9-2 and to facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain, standards developing organisations (IEC, CENELEC) and end users (electricity generators, network operators, utility companies).

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 research 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 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 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 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.